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DESCRIPTION OF THE SAVANNAH RIVER LABORATORY METEOROLOGICAL DATA BASE FOR 1975 to 1979

by

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16. ABSTRACT

A summary is presented of a meteorological data set collected during the period 1975 to 1979 by the Meteorology Group of the Savannah River Laboratory at the WJBF tower located 11 km southeast of Augusta, Georgia and 23 km southwest of Aiken, South Carolina. These data contain 15-minute averages and standard deviations of temperature, horizontal wind speed and wind direction, and vertical wind direction. The data were collected at seven elevations above ground, 10, 35, 91, 137, 182, 243 and 304 meters. The format of the data base is presented and a summary is given of the analyses conducted in the course of processing these data. These analyses include checks for consistency and suspect values. Also, analyses were conducted to detect diurnal and seasonal trends in the time series of data. The goal of these analyses was to aid in the assessment of data integrity. Dimensional analyses employing scaling lengths and velocities were not performed, as these were beyond the scope of laying a basic foundation for future studies.

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FORWARD

The Atmospheric Sciences Research Laboratory conducts a research program in the physical sciences to detect, define, and quantify the effects of air pollution on urban, regional, and global atmospheres. This includes research and development programs designed to quantify the relationships between emissions of pollutants from all types of sources and air quality and atmospheric effects.

The Meteorology and Assessment Division conducts research programs in environmental meteorology to describe the roles and interrelationships of atmospheric processes and airbourne pollutants in effective air, and land resource management.

The goal of this document is to summarize a 5-year data set of meteorological tower data collected by the Meteorology Group of the Savannah River Laboratory, Atomic Energy Division, E.I. du Pont de Nemours & Company. These data contain 15-minute averages and standard deviations of temperature, wind speed, horizontal wind direction and vertical wind direction recorded on the WJBF-TV tower at seven elevations above ground to a height of 304 meters. There are few such meteorological data sets available having this vertical resolution for such an extended period of record. These data will provide a unique and powerful means for the evaluation and improvement of dispersion estimation and characterization.

A. H. Ellison
Director
Atmospheric Sciences Research Laboratory

Abstract

A summary is presented of a meteorological data set collected during the period 1975 to 1979 by the Meteorology Group of the Savannah River Laboratory at the WJBF tower located 11 km southeast of Augusta, Georgia and 23 km southwest of Aiken, South Carolina. These data contain 15-minute averages and standard deviations of temperature, horizontal wind speed and wind direction, and vertical wind direction. The data were collected at seven elevations above ground, 10, 35, 91, 137, 182, 243 and 304 meters. The format of the data base is presented and a summary is given of the analyses conducted in the course of processing these data. These analyses include checks for consistency and suspect values. Also, analyses were conducted to detect diurnal and seasonal trends in the time series of data. The goal of these analyses was to aid in the assessment of data integrity. Dimensional analyses employing scaling lengths and velocities were not performed, as these were beyond the scope of laying a basic foundation for future studies. The report covers a period from January 1982 to August 1984 and the work completed as of September 1985.

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1.0 INTRODUCTION

1.1 Purpose

There are few meteorological data sets available from tall towers having an extended period of record. This document summarizes one such meteorological data set collected during the period 1975 to 1979 by the Meteorology Group of the Savannah River Laboratory (SRL), Atomic Energy Division, E.I. du Pont de Nemours & Company. These data contain 15-minute averages and standard deviations of temperature, horizontal wind speed and wind direction, and vertical wind direction. The data were collected on the WJBF tower at seven elevations above ground, 10, 36, 91, 137, 182, 243 and 304 meters.

This document is structured to serve the needs of those aiming to employ these data in analyses of their own and those reviewing the results gained already by this initial review of the data. Section 2 provides a brief description of the instrumentation and data handling employed to establish the original 15-minute averages and standard deviations of the various meteorological elements. This discussion and the summary of the flagging procedures instituted during our review of the data provides the technical information for assessing the suitability of these data for a particular investigation. Section 3 summarizes the data processing accomplished by this study. Data descriptions and formats are provided for the various computer files established on the EPA Sperry UNIVAC 1110 computer. These tables will prove useful to those accessing these files in later studies. The data were analyzed for consistency and those values that appeared suspect were flagged. In most cases, the suspect values are attributable to values below instrument threshold or beyond instrument

range. An inspection of the flagging procedures will reveal that the intent was to identify the most extreme values. Section 3 also outlines the procedures employed to estimate the surface fluxes and certain other parameters typically employed in meteorological analyses. Section 4 summarizes the trends and patterns seen in the course of the data processing. Plots were developed depicting the diurnal variation of the meteorological elements for each month. The goal of these analyses was to aid in the assessment of data integrity. Dimensional analyses employing terms such as mixing height, surface friction velocity or Monin-Obukhov length were not performed. These analyses were beyond the scope of this study. The intent was to lay the groundwork for the succeeding analyses.

1.2 Site Description

The WJBF -- SRL Meteorological Facility, is 11 km southeast of Augusta, Georgia, and 23 km southwest of Aiken, South Carolina. The 365 m tower, whose base stands 121 m above mean sea level, has been in use as a meteorological tower since October, 1965. It was then that SRL began its data collection program for reactor safety studies. The instrumentation and several features of the SRL program were summarized in Cooper and Rushe (1968). The instruments are mounted on heavy booms extending about 3 m outward (direction 225°) from the tower. Using the results of Gill et al. (1967), it was determined that the tower would significantly affect the measurements of wind direction in the 50° sector from 355° to 45°. In 1973, changes to the system were made to improve the handling of the data collected. The details of the system's renovations are contained in Crawford (1974). The most significant improvement was the addition of a

digital data acquisition system. The system monitors and records information from 32 channels of data directly on magnetic tape in a format compatible for processing with SRL's computer facility.

The WJBF tower is one of three TV-Radio towers near the rural community of Beach Island, South Carolina. There is no one dominant form of land use in the immediate vicinity of the tower. Along any given azimuth from the tower, the rolling terrain varies with pine tree forests (heights approximately 10 to 20 m), pastures and fields, and clearings of waist high scrub and young saplings.

Two major topographical features are the Savannah River and an intermittent stream called Long Branch. The broad Savannah River flows within 5.6 km to the west and within 9.7 [illegible]he south of the instrumented tower. The Long Branch stream flows from the northwest to southwest with its closest approach to the tower at about 610 m southwest at the tower, see Figure 1-1.

Data from the WJBF tower facility have been used to investigate the sensitivity of dispersion model results to spatial variability (Pendergast, 1982). Weber et al. (1982a) investigated the agreement between spectral scales and standard deviations of the fluctuating velocity components computed from the WJBF tower data with similarity theory model. Reasonable agreement was found given the nonhomogeneous terrain in the vicinity of the tower, which differs from the long uniform fetches assumed by models. The WJBF tower data have also been employed in comparison studies of various mesoscale atmospheric dispersion models (Weber et al., 1982b).

The terrain and ground cover in the vicinity of the tower is similar to much of the southeast piedmont region of the United States. Study of the climatology of these tower data should yield useful information of conditions experienced by sources of pollutant within this region. Those studies of dispersion conducted employing the tower data have not found the meteorological conditions dominated by the rolling terrain and varied land use. To the contrary, it has been found that the similarity scaling relationships are still useful descriptions even though such relationships are applicable strictly speaking to flat homogeneous terrain.

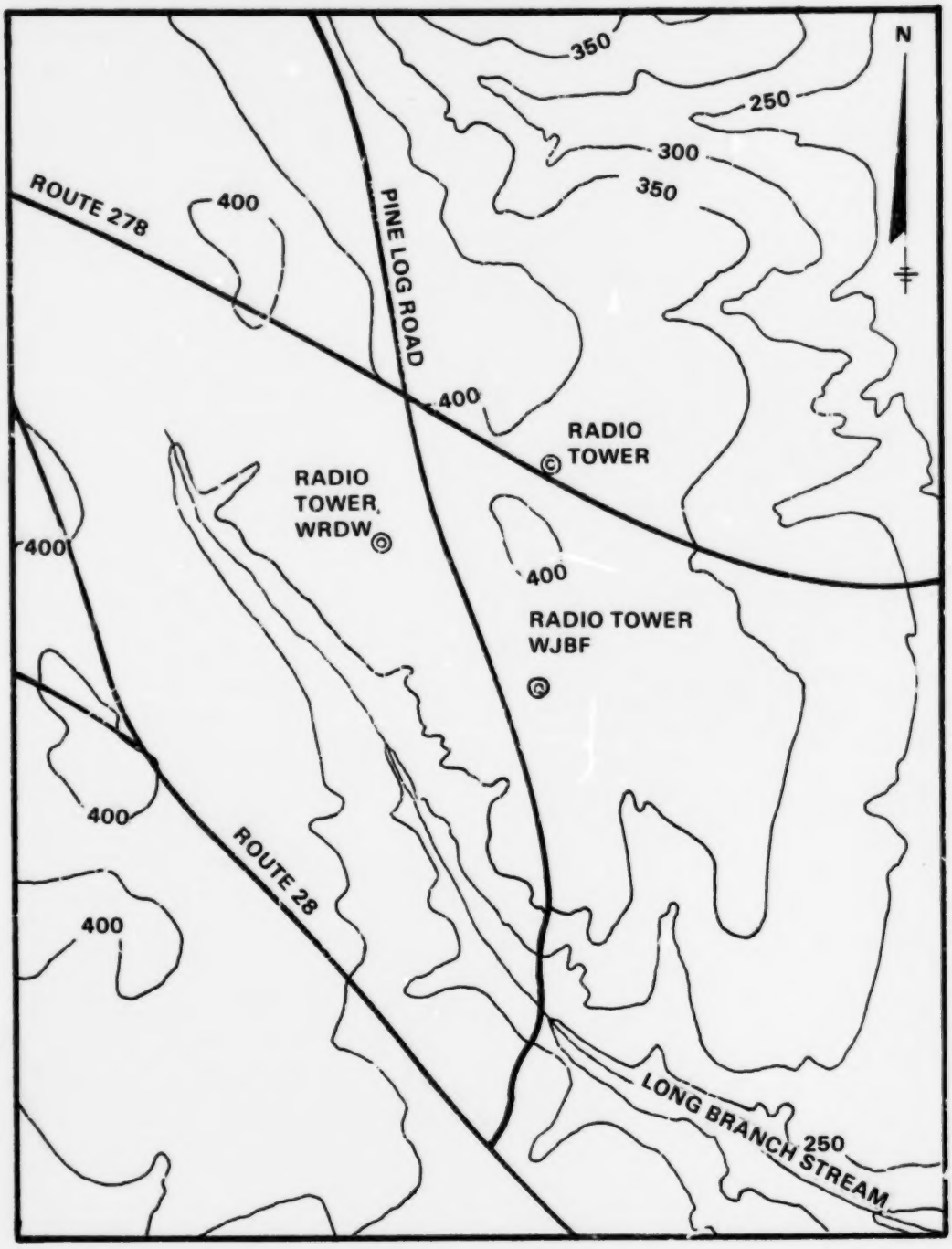

Figure 1-1. Terrain at SRL-WJBF tower. Scale is 2 5/8 inches equals one mile. Contours are for every 50 feet.

2.0 DATA DESCRIPTION

2.1 Overview

The data discussed spans the period from 1975 through 1979. There are three data types available: hourly National Weather Service (NWS) surface observations, twice-daily NWS upper-air reports, and WJBF tower data.

Table 2-1 lists the locations of the NWS stations mentioned in the later discussions. The locations listed in Table 2-1 are depicted in Figure 2-1. Table 2-2 summarizes the number of observations available at the NWS upper-air stations and the one NWS surface station processed. The data record for the NWS stations is nearly complete with one hour's observation missing in the surface station data and there are never more than 20 observations missing in any one station-year of upper air data.

Figures 2-2 through 2-6 summarize the amount of data available from the WJBF tower. This tower is located at 33.40°N and 81.79°W. A comparison of the results summarized in Figures 2-2 through 2-6 suggests that the consistency of the meteorological tower data varied some from one year to the next. Generally, if the mean value of the meteorological variable was accepted as valid, the reported standard deviation was also accepted as valid. Hence, within these figures results are presented only for the mean values. The record for certain variables is more complete than for other variables. For instance, for 1976 (Figure 2-3), 21 percent of the 15-minute data periods had no reports. For the 15-minute periods reported, the amount of missing data varied by meteorological variable and with tower level. An average of 21 percent missing for the vertical wind direction data to an average of 4 percent missing for the temperature data were found.

During the review of the tower data, some of the values were below instrument threshold or inconsistent with values reported at other levels. The details of the reviews conducted and resulting flagging procedures instituted are discussed later in section 3. It is worth noting here that for a year's data less than 3 percent of the values for any one variable were flagged and typically the flagging involved less than 1 percent of the values reported.

2.2 Summary of SRL Measurements

The WJBF tower is instrumented at six levels from 36 m to 304 m, with a separate 10-m tower (Figure 2-7), with bivanes and fast-response cup anemometers. Platinum resistance thermometers at each of the 7 levels from 10 to 304 m provide temperature measurement. Table 2-3 list the meteorological instrumentation.

The cup and bivane systems on the WJBF tower are mounted on the end of 6-m booms of heavy steel. The boom can move up and down and rotational. The boom is leveled within 1/500 of a degree and bolted in position.

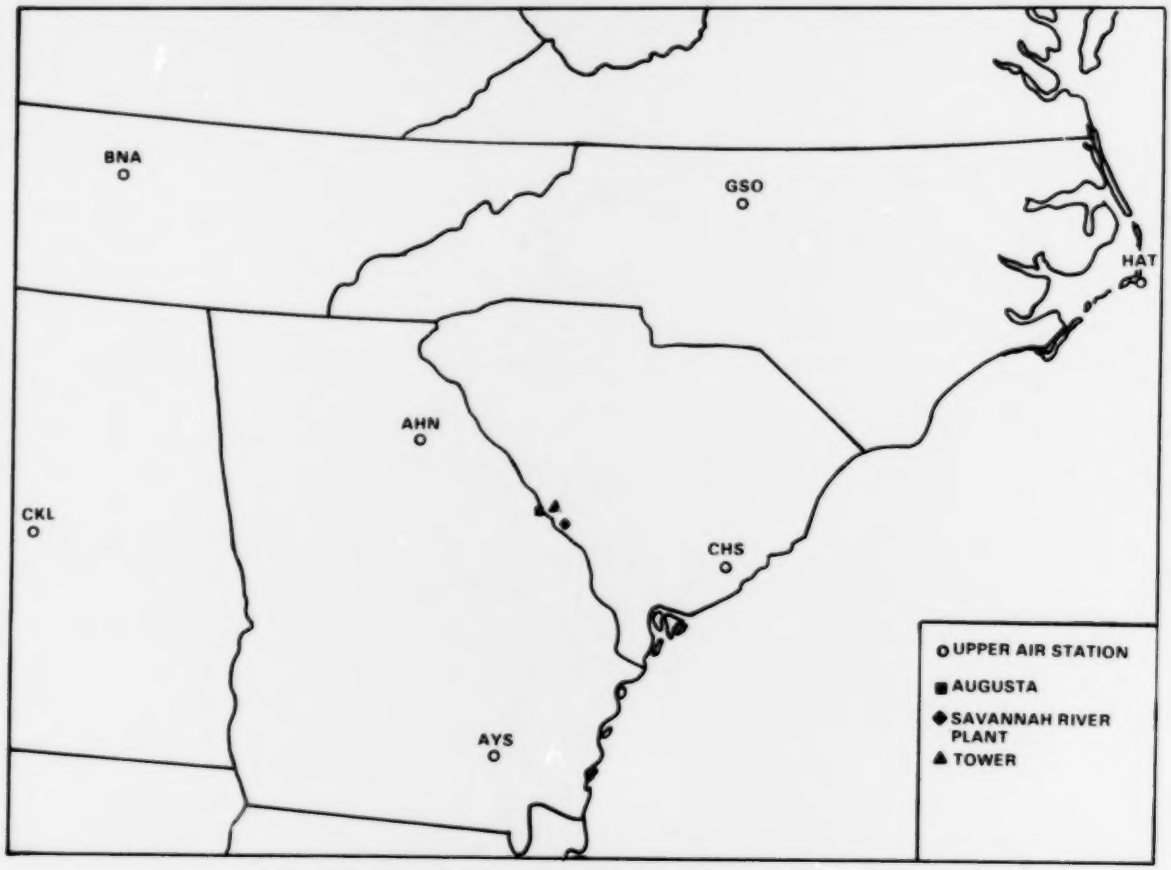

Figure 2-1. WJBF tower location relative to Augusta, Georgia, the Savannah River Plant in South Carolina and the NWS upper air stations in the vicinity.

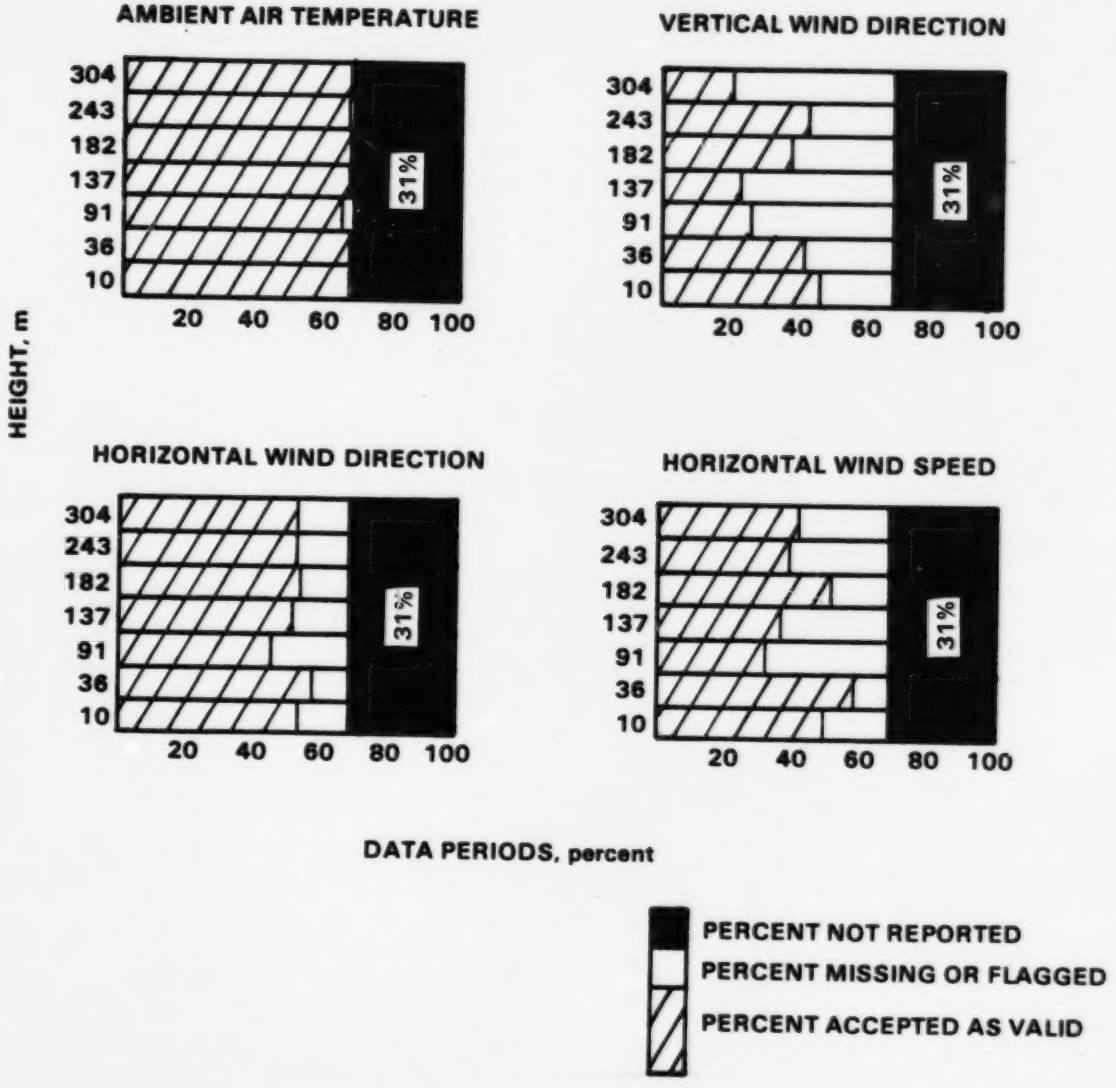

Figure 2-2. Summary of data reported for SRL meteorological tower for 1975 (35,040 15 -minute periods).

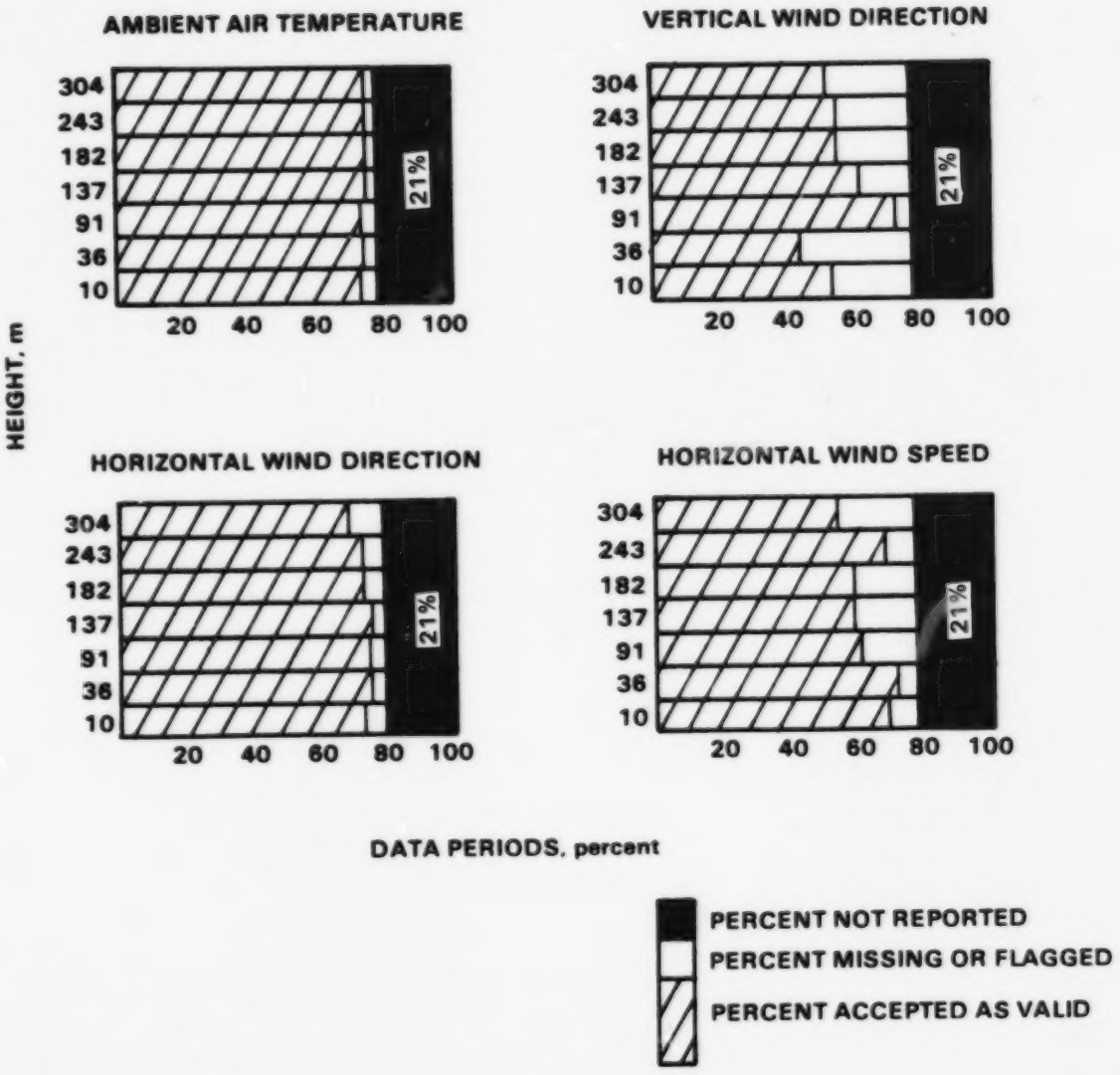

Figure 2-3. Summary of data reported for SRL meteorological tower for 1976 (35,136 15 -minute periods).

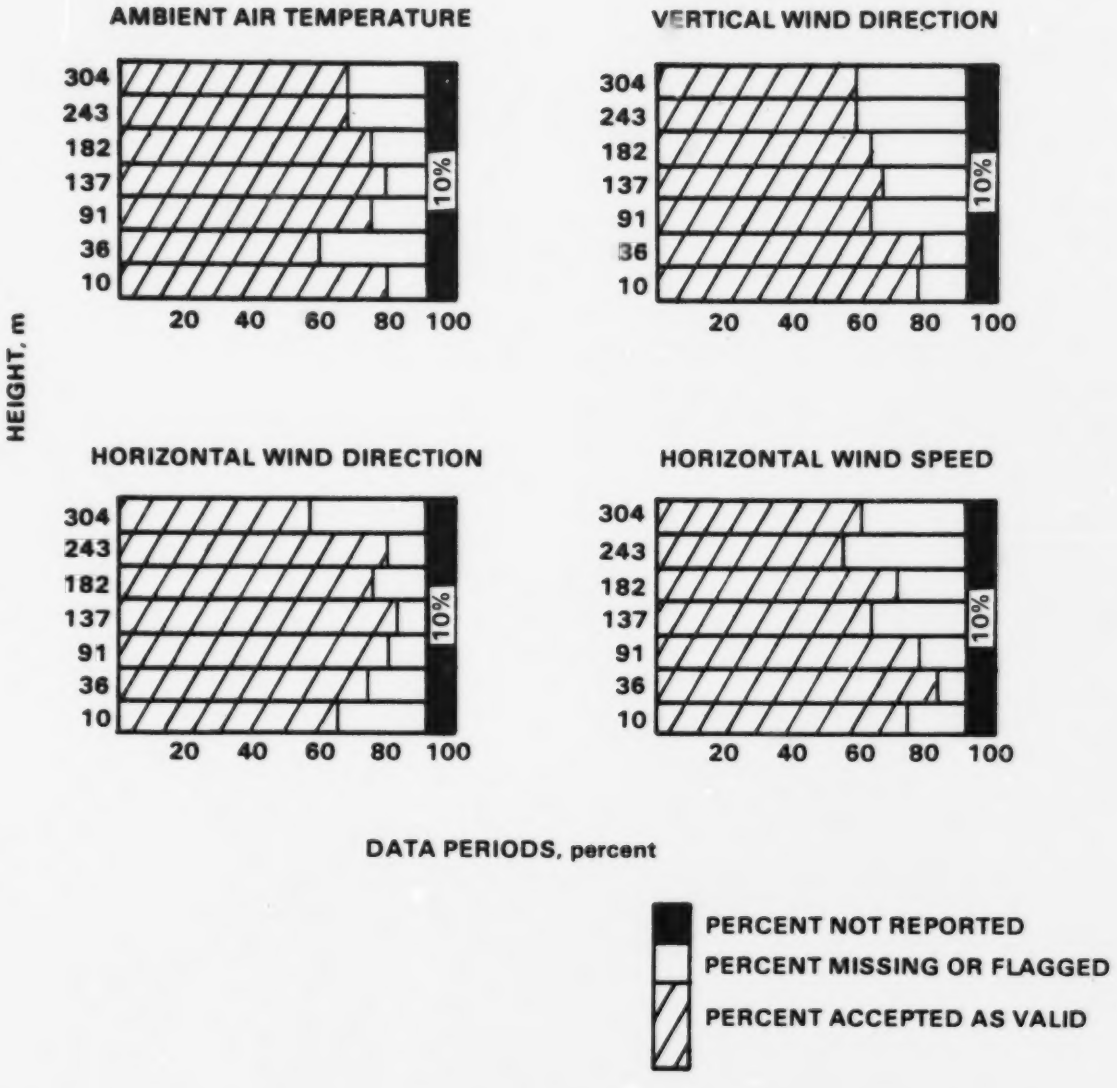

Figure 2-4. Summary of data reported for SRL meteorological tower for 1977 (35040 15 - minute periods).

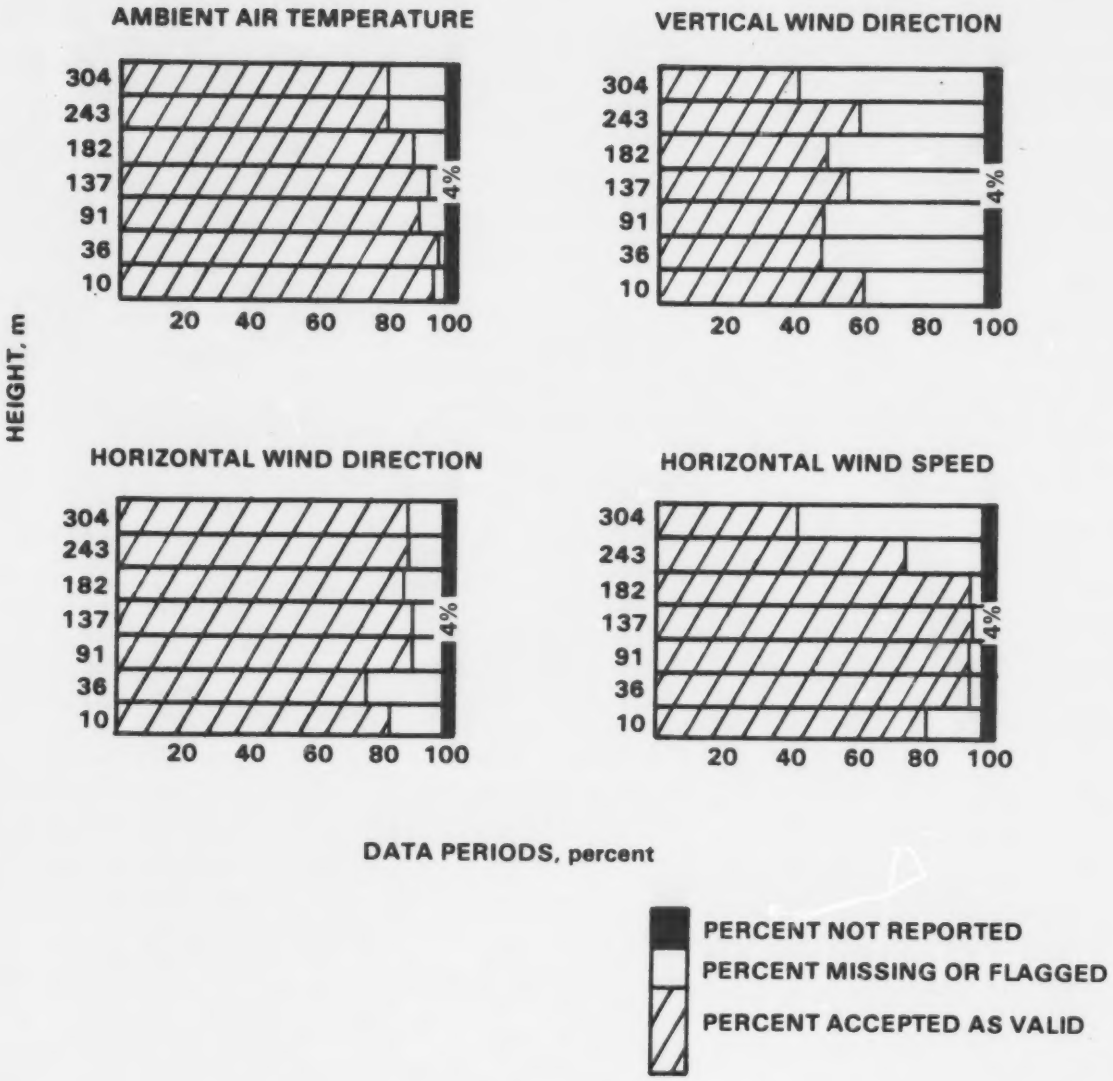

Figure 2-5. Summary of data reported for SRL meteorological tower for 1978 (35040 15 - minute periods).

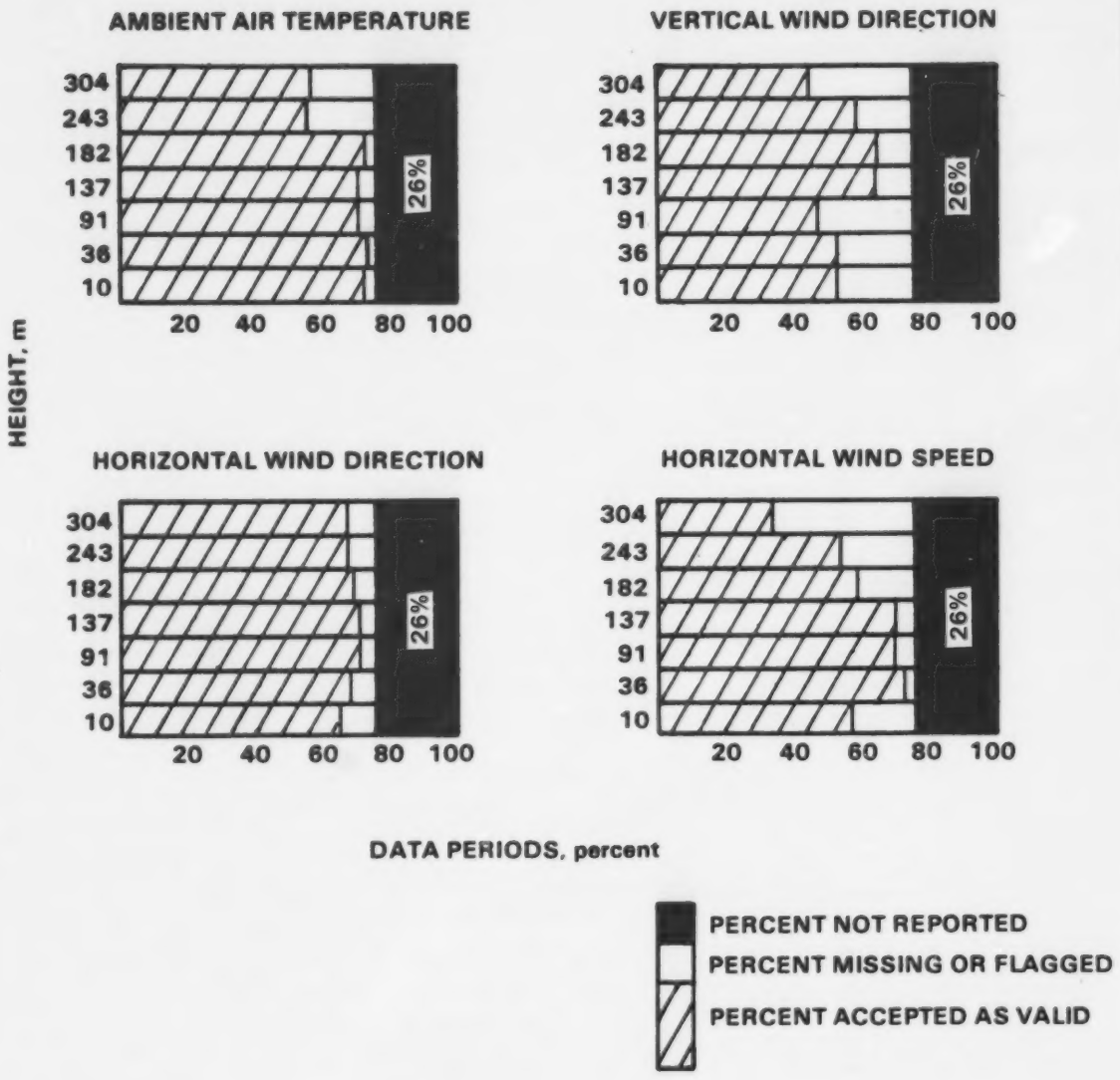

Figure 2-6. Summary of data reported for SRL meteorological tower for 1979 (35040 15 - minute periods).

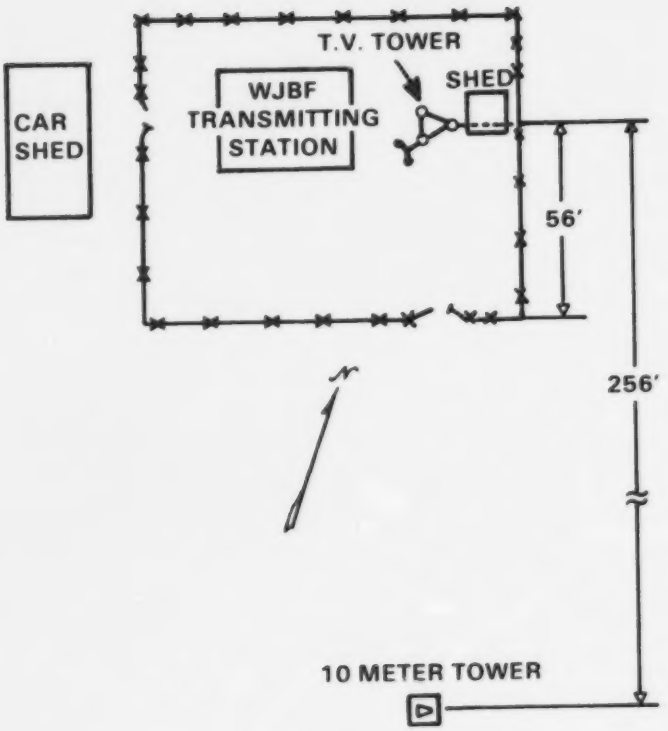

Figure 2-7. Location of meteorological instrumentation at the WJBF site.

Table 2-1. Locations of National Weather Service Stations in Vicinity of WJBF Tower.

Location	WBAN call letters	WBAN ID	International ID	Longitude	Lattitude	Elevation (MSL), m
Athens, GA	AHN	72311	13873	33.95° N	83.32° W	247
Augusta, GA	AGS	72218	3820	33.37° N	81.97° W	45
Cape Hatteras, NC	HAT	72304	93729	35.27° N	75.55° W	3
Centerville, AL	CKL	72229	3881	32.90° N	87.25° W	140
Charleston, SC	CHS	72208	13880	32.90° N	80.03° W	15
Greensboro, NC	GSO	72317	13723	36.08° N	79.95° W	270
Nashville, TN	BNA	72327	13897	33.25° N	86.57° W	180
Waycross, GA	AYS	72213	13861	31.25° N	82.40° W	46

Table 2-2. Summary of Number of Observations Available from NWS Stations

Station	1975	1976	Year 9177	1978	1979
		Hourly Surface Data			
Augusta, GA	8760	8784	8760	8760	8759*
		Radiosonde Data			
Athens, GA	722	726	730	730	728
Cape Hatteras, NC	708	727	728	730	719
Centerville, AL	718	724	714	720	725
Charleston, SC	727	678	730	729	730
Greensboro, NC	711	723	728	720	729
Nashville, TN	723	726	729	730	727
Waycross, GA	726	730	729	729	725

*Missing observation for hour 0300 July 14.

Table 2-3. Meteorological Instrumentation on the WJBF Tower.

Manufacturer	Instrument Type	Parameter	Accuracy	Threshold
CLIMET	Bivane	Azimuth	3°	0.34 m/s
CLIMET	Bivane	Elevation	3°	0.34 m/s
CLIMET	Cup Anemometer	Wind Speed	The greater of 1% or 0.07 m/s	0.27 m/s
CLIMET	Platinum Resistance Thermometer	Temperature	1.0 C	

3.0 DATA PROCESSING

3.1 Processing Overview

This section summarizes the steps taken to construct data sets for processing on the EPA UNIVAC 1100 computer. As the data came from several sources in different formats, the first steps taken were to rewrite the data into convenient formats for the succeeding analyses. Those values deemed suspect within the SRL tower data were flagged in a manner that retained access to the original values. Suspect values within the NWS data typically could be attributed to keypunch errors that were easily identified by a comparison with adjacent values in time or space. Those values identified as keypunch errors were replaced with corrected values.

In this section the emphasis is on defining the procedures employed in the quality assurance of the data. The results summarizing the flagging procedures were shown in Section 2. The results of the other analyses performed are presented in Section 4.

3.2 Extraction Procedures

3.2.1 NWS hourly surface data

The hourly surface weather data were in the WBAN (Weather-Bureau-Air Force-Navy) hourly surface observation CD144 format. This format contains overpunches in the specification of some of its values. For instance, a dry bulb temperature below zero degrees F is indicated by an over-punch. To facilitate use of these data, the WBAN reports were decoded if it was thought they would find repeated use in later analyses. A FORTRAN unformatted file was established for each station-year of data. Each record

in the file is the complete observation for one hour. A sample read statement for a FORTRAN program and a definition of the variables are provided in Table 3-1.

3.2.2 NWS radiosonde data

The radiosonde data were in the WBAN TDF 5600 format. In the process of reading and reformatting these data, the data were organized into separate files, one FORTRAN unformatted file for each year. After separation by year, the data were sorted by day and launch time. This facilitates processing all seven station's data for a given day at once. Each record in the file is the complete observation for a radiosonde launch. A sample read statement for a FORTRAN program and a definition of the variables are provided in Table 3-2. Note: For proper reading of the radiosonde data files, all dimensioned variables must be dimensioned 79.

3.2.3 Savannah River Laboratory data

The WJBF tower data were separated into one FORTRAN unformatted data file for each month. The data were sorted by date and time. Duplicate records were eliminated and the data were verified by visual inspection to be in the correct order. Histograms of the data values at each level for each variable were produced for each month. Histograms were generated summarizing the differences that occurred between adjacent values in time and in space. These results were evaluated to establish the criteria for defining suspect values for flagging. After flagging, the series of reports and analyses were reproduced and inspected to assess the impact of the flagging criteria. A sample read statement for a FORTRAN program and a definition of the variables are provided in Table 3-3.

3.3 Flagging Procedures for WJBF Meteorological Data

3.3.1 Overview

As often occurs in the review of data values from large sets, some values are deemed of questionable validity. In such cases, one has the choice of either eliminating these values from the data set or annotating them in some manner. The latter procedure is often referred to as "flagging". The reasons for flagging any single value are legion. We have chosen to flag questionable values by 1) adding 2000 to the original value and 2) assigning a specific code word to the value. This code word, when used with the appropriate key, tells the reason for the flagging. The user does not have to decode the code word unless he wants the reason for flagging. Since all the original data values contain, at most, three digits in front of the decimal, no significance was lost by the addition of the 2000. The code word was left blank for unflagged data values. If the user wishes, the flagging can be ignored altogether and the original data set can be rebuilt by subtracting 2000 from all flagged values.

3.3.2 Flagging hierarchy

As data sets are subjected to greater scrutiny, the questionable nature of individual values becomes manifest. Hence, we could view flagging as a hierarchy of criteria which, when met, define valid data, with the numeric value of the flag determining its level within the hierarchy. For example, criteria that apply to any value within any year, are referred to as yearly criteria and they constitute the crudest level of the flagging hierarchy. As the applicability of the criteria become more exacting, (for example, monthly, daily, hourly) the data values are tested more stringently. In

the flagging procedure instituted, the code word shows both the reason and the level of hierarchy (yearly, hourly, etc,) of the flag so the user can know how stringent a criteria was applied to each particular flagged value. Furthermore, if a value was flagged by criteria too harsh for the user, all flags of that level can be removed, while not disturbing those of a less restrictive character. Thus, the code word allows for deflagging and other special actions by the user.

3.3.3 Code word specification

The code word is an 8-digit integer of which only the last 5 digits have been used by the authors. The first three were left blank to allow users to develop special flags as they see the need in their use of the data.

code word

for special actions by the user	Five digits which tell the level and reason for flagging

If the data value corresponding to this code word is greater then 1000, then it is flagged and at least one of the code word's digits in nonzero. The first nonblank digit (reading from the right) represents the level of flagging and always lies between 1 and 4 inclusive. The higher this digit is, the more stringent the flag:

1 = 1st order (yearly or monthly criteria)

2 = 2nd order (weekly criteria)

3 = 3rd order (diurnal criteria)

4 = 4th order (hourly or single period criteria)

The specific reason for flagging can be found by indexing the code word's 5-digit number with the corresponding description in Table 3-4.

EXAMPLE. The code word _ _ _ _ _ _ 10 from June 1976 indicates a value flagged because its "level difference" (explained in section 3.3.4) is out of range.

3.3.4 Flagging key

Table 3-4 contains written descriptions of the reasons for flagging that reference certain arbitrary range limits determined during the quality assurance of the data. These limits were determined through comparison of monthly histograms of the SRL tower data with the NWS climatological data for Augusta, Georgia. The range limits are listed in Table 3-5 by variable and month.

The flagging of data values whose differences with other levels were out of range called for a special check to determine that the correct values were left unflagged. Since one bad value spoils two-level differences, (above and below) flagging was done in such a way as to produce a minimum of flagged values per 15-minute period. The flagging software independently kept track of the two ways of flagging each level difference, and then applied the one which resulted in fewer flagged values. Because of its unique range of values, the horizontal wind direction level-to-level differences required a separate flagging algorithm which reduced the variance of the unflagged data to a minimum.

3.3.5 Flagging results

Only first order flagging criteria have been established at this time. It is anticipated that criteria will be developed for the other levels of flagging as the data find use in other research studies.

As an aid in assessing the impact of the flagging procedures, time series of 1976 meteorological data were constructed for visual inspection. Figures 3-1 and 3-2 are examples of such plots. Temperature and wind speed for the first week in January 1976 are shown. All seven levels of the data are depicted. The large numbers on the vertical scale indicate the level number, the larger the number the higher the level. The central point of the range of values is indicated as the numbered tic mark. The upper panel of each figure depicts the raw data, and the lower panel of each figure depicts the same data with flagged values removed. The circled portions of the time series highlight portions of the data record in which suspect values were detected in the flagging procedures. In some cases, the reasons suspect values were detected are obvious, as the raw times series contains spikes. For example, the temperatures at levels 6 and 7 during day 6 in Figure 3-1 have spikes. In some cases, the circled portions of the time series appear to be in accord with adjacent values. In these cases, the reasons for the flagging can be traced to the flagging comparisons which checked the level to level differences and which checked for values out of range.

3.4 Parameter specification

Atmospheric dispersion is controlled by the turbulence in the air. The parameters describing the scales of turbulence therefore are of fundamental importance in a description of atmospheric dispersion. The

meteorological instrumentation necessary to directly specify these scaling parameters is typically not available except during research field studies. In lieu of such measurements, the scaling parameters are specified through the use of semi-empirical relationships employing more easily obtainable meteorological data. It was not the purpose of this effort to analyze the SRL tower data in terms of these parameters. However, it was felt that it would be worthwhile to explore on part of the data base the specification of some of these scaling parameters. Such an analysis would provide insight into the difficulties to be encountered in specifying the scaling parameters with the available data.

3.4.1 Surface roughness length

Previous studies conducted during 1974 at the WJBF tower have shown the fetch to the south of the tower to have a roughness length of approximately 0.08 m and the fetch to the west and southwest to have a roughness length of 0.36 m (Weber et al., 1975). Wieringa (1973) suggests that the roughness length can be estimated using measurements of the standard deviation of the wind speed fluctuations, s_u, along the mean wind direction,

$$s_u/u = 1/\ln(z/z_o), \qquad (3\text{-}1)$$

where u is the mean wind speed measured at height z and z_o is the roughness length. This roughness length estimate is defined as the "effective" roughness length and characterizes the upwind fetch for about 5 km. Wieringa and others have demonstrated that the "effective" roughness length is the appropriate value for use in wind profile estimates using similarity relationships. The estimation procedure involves only cases when the wind speed is strong (5 m/s or more). This procedure appeared well suited to the data collected at the 10 and 36 m levels on the tower.

3.4.2 Surface energy fluxes and the Monin-Obukhov length

Where the primary meteorological data available are the standard weather observations, the values of the Monin-Obukhov length, L, the surface friction velocity, u_*, and the surface heat flux, H, can be estimated following the procedures discussed by Holtslag and Van Ulden (1982a,b,). The procedurer parameterize the surface energy fluxes in terms of cloud cover, time of day, near-surface wind speed, air temperature, and surface roughness. Monin-Obukhov similarity relationships are then used to estimate L, u_*, and H as continuous variables of the parameterized surface energy fluxes. This procedure could be implemented using the cloud cover reports from Augusta and the 10-m tower wind speed and temperature data.

3.4.3 Pasquill stability category

With the data available, there are several procedures possible for specifying the Pasquill stability category. We chose to implement the procedure described by Turner (1964) which defines the stability category in terms of the cloud cover, ceiling height, time of day and near-surface wind speed. The cloud cover reports from Augusta and the 10-m wind speeds at the tower fulfill the data requirements to employ this procedure.

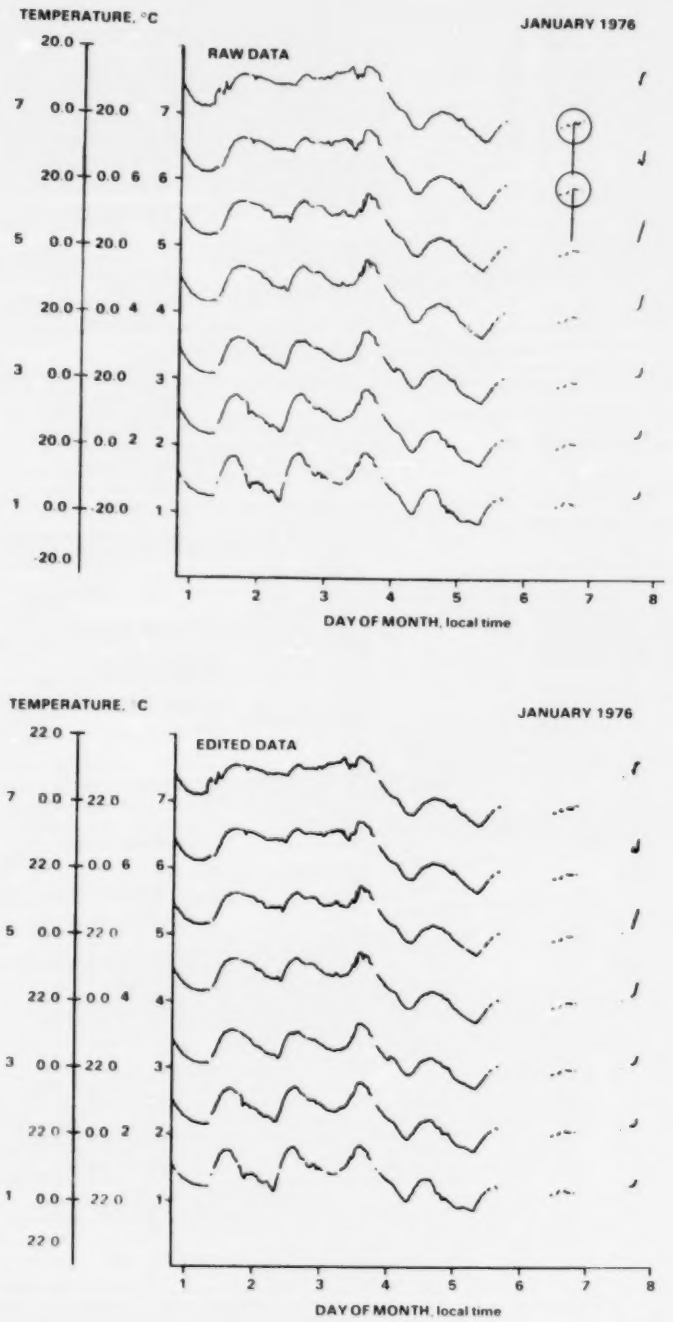

Figure 3-1. Time series of temperature data for first week of January 1976. In the top panel, all values are shown. In the lower panel, the suspect values have been removed.

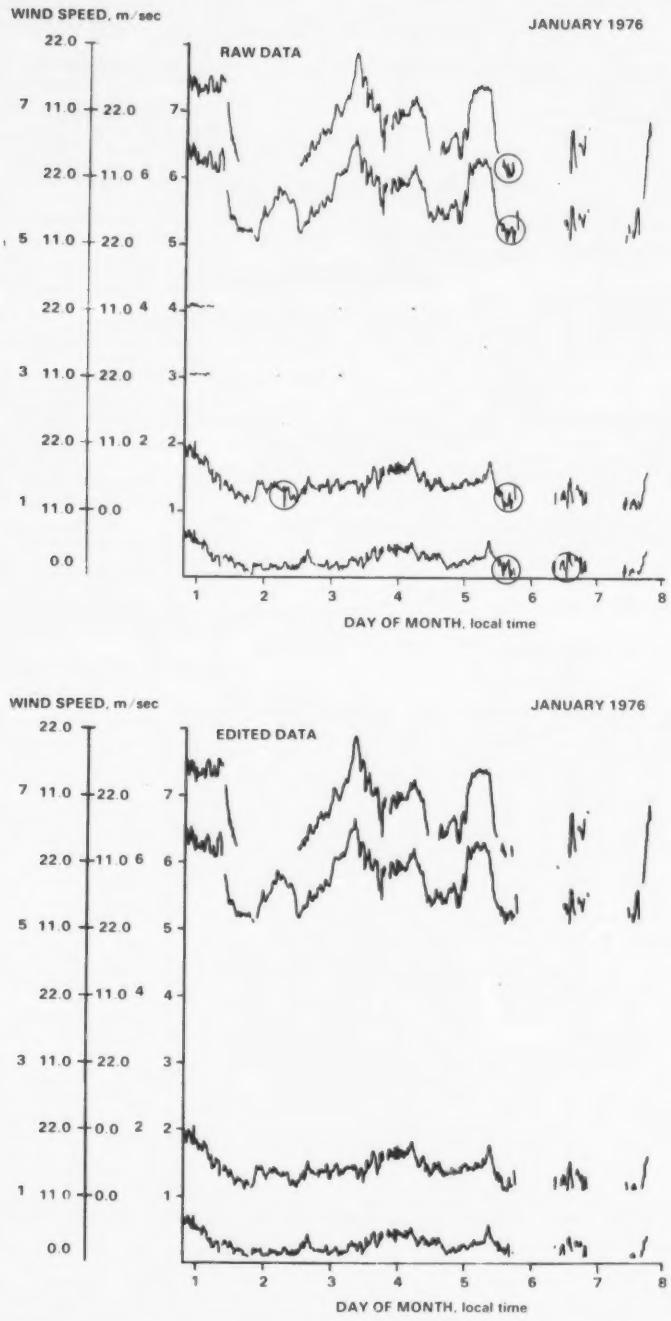

Figure 3-2. Time series of wind speed data for first week of January 1976. In the top panel, all values are shown. In the lower panel, the suspect values have been removed.

Table 3-1. Sample Fortran Read and Data Dictionary for NWS Surface Data Files.

READ(UNIT#) ISTNO, IYR, IMO, IDY, IHR, ICHGT, ISCON, IVSBY, IWETH, P, DEWPT, DIR, WSP, SP, DRYB, WETB, RH, ITSC, LA(1), LCT(1), LLH(1), (LA(K), LCT(K), LLH(K), LSA(K), K = 2,4)

Variable Name	Description
ISTNO	5-digit WBAN station number
IYR	Last 2 digits of the year
IMO	Month (1 = January, 12 = December)
IDY	Day of month
IHR	Hour (LST, 1-24)
ICHGT	3-digit ceiling height (hundreds of feet)
ISCON	4-digit sky condition code
IVSBY	3-digit visibility code
IWETH	8-digit weather code
P	Sea-level pressure (mb)
DEWPT	Dew point temperature (F)
DIR	Wind direction (tens of degrees)
WSP	Wind speed (kts)
SP	Station pressure (inches of mercury)
DRYB	Dry bulb temperature (F)
WETB	Wet bulb temperature (F)
RH	Relative humidity (percent)
ITSC	Total cloud amount (tenths, col. 56 of the surface WBAN report)
LA(1)	Lowest layer cloud amount (tenths)
LCT(1)	Lowest layer cloud type code
LLH(1)	Lowest layer height (hundreds of feet)
LA(K)	Cloud information
LCT(K)	for the next three
LLH(K)	levels if present
LSA(1)	Dummy variable (has no meaning)
LSA(K)	Sum from J = 1 to K of LA(K)

Notes:

1. Missing data are indicated as -99.
2. Sky condition (ISCON) is 9000 × code if overpunches were present in the original data.
3. ICHGT = 1000 if height was indicated as unlimited in the original data.
4. If no clouds were reported but data are reported for the lowest layer, LLH(1) was set to 1000.

Table 3-2. Sample Fortran Read and Data Dictionary for the NWS Surface Data Files.

READ(UNIT#) ISTA, IYR, JDAY, IMO, IDA, IHR, NL, P, H, T, RH, DIR, SPD, IN, IK	
Variable Name	**Description**
ISTA	5-digit WBAN station number
IYR	Last 2 digits of the year
JDAY	Julian day number
IMO	Month (1 = January, 12 = December)
IDA	Day of month
IHR	Hour (00 = 0000 GMT, 12 = 1200 GMT)
NL	Number of levels in sounding
P	Pressure (mb)
H	Height (m)
T	Temperature (C)
RH	Relative humidity (percent)
DIR	Wind direction (nearest degree)
SPD	Wind speed (m/s)
IN, IL	Height code and temperature code. Blank = data as reported, 1 = data computed, 2 = data recomputed during data audit.
Notes:	1. The data files were constructed with P, H, T, RH, DIR, SPD, IN and IK dimensioned 79. 2. Missing data are indicated as -999.

Table 3-3. Sample Fortran Read and Data Dictionary for the WJBF Meteorological Data Files.

READ(UNIT#) (I HEAD(K), K = 1, 5), ((DATA(L, M), M = 1, 7), L = 1, 8), ((ICODE(L, M), M = 1, 7), L = 1, 8)

Variable Name	Description
I HEAD(1)	Month-day-year group (10276 = January 2, 1976)
I HEAD(2)	Day of month
I HEAD(3)	Minutes of start time
I HEAD(4)	Seconds of start time
I HEAD(5)	Start time group (1245 = 12:45 GMT)
DATA(L, M)	Meteorological data
	L is the index for variable. M is the index for height.
I CODE(L, M)	Flagging code (Section 3.3)

M	Height (m)	L	Variable
1	10	1	Temperature (C)
2	36	2	S.D. of temperature (C)
3	91	3	Wind speed (m/s)
4	137	4	S.D. of wind speed (m/s)
5	182	5	Horizontal wind direction (°)
6	243	6	S.D. Hor. wind direction (°)
7	304	7	Vertical wind direction (°)
		8	S.D. vertical wind direction direction (°)

Table 3-4. Flagging Key Codes Developed for the SRL Data.

Code Number	Reason for Flagging
-----	Value not flagged.
First order keys (yearly or monthly criteria)	
----1	Data value is above or below expected range.
---10	The difference computed between this data value and the value reported at the next level below is out of range.
---11-11111	Not used.
Second order keys (weekly criteria)	
Future use	
Third order keys (hourly criteria)	
Future use	
Fourth order keys (single period criteria)	
Future use	

Table 3-5A. Flagging Criteria for Average Values.

Variable	Range Criteria Minimum	Range Criteria Maximum	Level Difference Criteria Minimum	Level Difference Criteria Maximum
Temperature (C)				
Month				
1	-14	27	-10	10
2	-10	32	-10	10
3	-8	34	-10	10
4	-5	38	-10	10
5	0	41	-10	10
6	6	43	-10	10
7	6	43	-10	10
8	0	41	-10	10
9	-5*	38**	-10	10
10	-8	34	-10	10
11	-10	32	-10	10
12	-10	37	-10	10
Wind Speed (m/s)	1.0	-	-10	10
Azimuth (degrees)	-	-	-100	100
Elevation*** (degrees)	40	80	-30	30

* Limit set to 1.0 C for 1978.

** Limit set to 36.5 C for 1979.

*** Level equals 60 degrees.

Table 3-5B. Flagging Criteria for Standard Deviation of Values.

Variable	Range Criteria		Level Difference Criteria	
	Minimum	Maximum	Minimum	Maximum
Temperature (C)	-	-	-1.6	1.6
Wind Speed (m/s)	-	3	-2.5	2.5
Azimuth (degrees)	-	-	-35	35
Elevation*** (degrees)	-	-	-45	45

4.0 DATA ANALYSIS AND RESULTS

4.1 Surface Parameters

4.1.1 Surface roughness length

The effective roughness length was estimated for those 15-minute periods when the 10-m wind speed was greater then 5 m/s, as discussed in Section 3.4.1. The results were summarized for each month within 30-degree sectors about the tower. Table 4-1 list the results for those sectors having at least 30 cases for analysis. The median value for the 10-m level results is 0.26 m with 50 percent of the values between 0.20 and 0.30 m. The median value for the 36-m level results is 0.33 m with 50 percent of the values between 0.27 and 0.35 m.

4.1.2 Surface fluxes

For each 15-minute period, the surface friction velocity, u*, and the surface heat flux, H, were estimated using the procedure outlined by Holtslag and Van Ulden (1982a,b), as discussed in Section 3.4.2. A roughness length of 0.30 m was used for this analysis. Tabulations were developed to depict the diurnal variation of the values estimated for u*, H and L for each month during 1976. Owing to missing temperatures or wind speed values at the 10-m level, there were fewer than 50 cases available for some of the hours. For the months of July, August and September there were as many as 12 of the 24 hours having fewer then 50 cases available for analysis. Tables 4-2 through 4-4 list the median values. Figures 4-1 through 4-3 depict results for February and June. These were two months with relatively complete records and were deemed representative of a winter and summer month. Comparison of the heat flux results listed in Table 4-3, suggest that March

and December deviate from the other months. The afternoon upward heat flux values suggest less heating and this is reflected in estimates of more neutral stability conditions (see Table 4-4). It is difficult to assess whether these results are real or are an artifact of the estimation procedure.

To better understand these results, a study was made of the sensitivity of the estimation procedure to cloud amount and to the choice of empirical constants employed within the estimation procedure. As discussed in Holtslag and Van Ulden (1982a), the sensible heat flux, H, and the net radiation, Q*, are related by,

$$H = \frac{(1-A) + S}{(1+S)} (Q^*-G) - B, \qquad (4-1)$$

where A and B are empirical constants, G is the soil heat flux and is typically approximated as $0.1Q^*$. S is the thermo-dynamic function of temperature which can be approximated as,

$$S = \exp[\ (279.57 - T)/17.78], \qquad (4-2)$$

where T is the 10-m air temperature (K). The upward heat flux is sensitive to the surface albedo. The albedo was set to a constant value of 0.23 in these analyses as suggested by Holtslag and Van Ulden. During wet conditions A is typically chosen to be 1.0 with B equal to 0. During dry conditions, Holtslag and Van Ulden suggest 0.65 and 20 W/m^2 for A and B, respectively. The incoming solar radiation is primarily a function of cloud amount and the angle of the sun above the horizon. Figure 4-4 illustrates the variation in estimated heat flux due to the choice of A in Equation (4-1). With a sun angle of 45 degrees above the horizon, these results are typical of midafternoon in February. There is a variation of upward heat flux amount of

a factor of 3, as A varies from 1 to 0. Cloud amount becomes important once the sky is more than half covered. Figure 4-5 illustrates the sensitivity of the heat flux estimates to sun angle and cloud amount. From Figure 4-4, it can be seen that until the cloud amount reaches five tenths coverage, there is little change in the results. At 5 tenths coverage, as cloud amount increases, the results rapidly collapse to those shown for 10 tenths coverage. Thus, the heat flux estimates change dramatically for changes in cloud amount from 4 tenths to 6 tenths coverage.

The values of surface friction velocity, u*, and Monin-Obukhov length, L, can be resolved using surface similarity relationships once the heat flux is determined. The Monin-Obukhov length is,

$$L = -u^{*3}/[k(g/T)(H/rc_p)], \tag{4-3}$$

where k is the von Karman constant (0.41), r is air density and the other variables have their usual meaning.

To further investigate the sensitivity of the results, the Monin-Obukhov length was estimated using A = 0.65 and 0.30, for the daytime hours for the month of June 1976. Figure 4-6 depicts the results for A = 0.65. The dashed-dot line is a least-squares fit for the results with A = 0.30. Inspection of the results reveals the decrease in the magnitude of L, as A decreases from 1 to 0.30, is almost entirely explained by the resulting increases in H. This results because during unstable conditions, the surface friction velocity is insensitive to changes in heat flux. At a height of 10 m and a surface roughness length of 0.3 m, ku/u* varies from 3.2 to 2.2 as L varies from -100 to -5. This is an increase in u* of only 45 percent for a factor of 20 decrease in L.

4.1.3 Pasquill stability category

In the preceding discussion on the estimated surface fluxes, one of the disconcerting issues was that there was no independent check of how well the surface fluxes were estimated. There are several studies available in the literature comparing the Monin-Obukhov length and the turbulence intensities at 10-m with Pasquill categories. Agreement between these studies and our results would provide circumstantial evidence for the veracity of the Monin-Obukhov estimation procedure.

Table 4-5 summarizes the comparison results. A surface roughness length of 0.3 m was used in developing the L-estimates using Golder's (1972) procedure. Estimates were then developed for the vertical and lateral turbulence intensities using the Golder L-values and the surface layer similarity relationships summarized by Binkowski (1979). Owing to missing or suspect data, the number of 15-minute data periods (N in Table 4-5) varied somewhat from one analysis to the next. One might wonder how L could be positive during the daytime as seen by the 75 percent quartile results. This occurs because the definition for day and night is based on time relative to sunrise and sunset for the Pasquill categories. Whereas, the upward heat flux estimates considers the sun's angle above the horizon as well as cloud amount. For fractional cloud amounts below 0.74, the sun's angle must be at least 13 degrees above the horizon before the heat flux becomes positive. For Augusta, Georgia the course of the noon sun varies from 72 degrees above the horizon in July to 33 degrees in December. As cloud amount increases, the critical angle increases from 13 to 23 degrees for overcast conditions. Thus, cloudy conditions near sunrise or sunset would result in negative heat flux estimates which in turn would result in positive positive L-values to be estimated during "daytime" Pasquill stability categories.

The Golder estimates of L, listed in the second half of Table 4-5, are in reasonable agreement with the values developed using Holtslag and Van Ulden's procedures. The agreement could be improved by altering the constants A and B in (4-1). The values employed were A = 0.65 and B = 20 W/m^2. However, given that the Golder values are coarse estimates in themselves, such adjustments are not warranted. What is instructive is the range of values in L, s_e and s_a associated with each Pasquill stability category. Also to note is the large variation seen in the values of L, s_e and s_a between the daytime and nighttime neutral cases.

4.1.4 Turbulence intensities

In Table 4-5, theoretical estimates of turbulence intensity are compared with those observed after stratification by Pasquill category. The turbulence values estimated using the Golder L-values are seen to agree with the median values observed for each Pasquill category. For further investigation, scatter plots were developed of the observed vertical and lateral turbulence intensities. These results, shown in Figures 4-7 and 4-8, reveal several very interesting issues.

The group of s_a values less than 2 degrees should have been labeled as suspect and excluded from the analysis. These erroneous values were not detected when the flagging thresholds were developed.

There is a noticeable lack of L values in the vicinity of L equal to 15 m. Values of L of 15 m or less result during the most stable conditions when the wind speeds are less than 3 m/s. In Figure 4-9 are depicted the estimates of L obtained for cases of 10-m wind speeds from 1 to 3 m/s for three cloud cover amounts. The kink in the depicted results is the point at which the low-wind speed algorithm is forced to match the general solution.

Where the slope in the results is very steep, notably to the right of the kinks, it is unlikely these L-values will be estimated. The wind speed above which the interpolation formula is no longer used, varies as a function of cloud cover amount, but the handoff always occurs for L-values in range from 12 to 16 m. This characteristic to effect a very narrow range of L-values, results in an apparent lack of L-values estimated at 15 m. Once L is below 30 m or so the exact value is of less concern than knowing that conditions are very stable and L is on the order of 30 m or less. Hence, this bias to not estimate values of 15 m is of little concern in practice.

Another feature evident in Figure 4-7 is the group of high s_a values during near-neutral conditions ($1/L \sim 0$), which seem to range in value from 22 degrees to 50 degrees. The s_e results, Figure 4-8, also evidence a similar behavior, although the lower bound in not as clearly marked as is the case for the s_a results. Several special analyses were conducted for all the cases with s_a above 25 degrees and L greater in magnitude than 40 m. Initially, it was suspected that these cases might reflect the occurrence of inclement weather, such as rainstorms associated with frontal passages. Of the 18767 cases satisfying the L-value limits, 1325 of these have s_a values greater than 25 degrees. Stratification of these 1325 cases by wind speed and wind direction revealed that characteristically the wind speeds were greater than 2 m/s with 592 of the cases (45 percent) having wind directions between 240 and 300 degrees. About 50 percent of the 1325 cases occurred on days when rain was reported at the national weather station at Augusta. The strongest discriminate was wind direction followed next by wind speed. Of course this might simply reflect the underlying population distribution of favor winds from the west. The probability of occurrences

of wind directions with wind speeds above 2 m/s was computed using all 18767 cases. These results were used to estimate the number of occurrences of wind direction one would anticipate for a sample size of 1325. Subtracting the projected values, based on the underlying population, from those observed provides a means for assessing whether the large number of cases having westerly winds simply reflects the overall wind rose. Figure 4-10 depicts the residuals (observed number of cases minus projected number of cases) for wind directions between 240 and 300 degrees. The scatter for wind directions other than westerly was typically plus or minus 3 cases; occasionally there were as many as 5 cases. In Figure 4-10 it is seen that for wind directions from about 269 to 285 degrees, there appears to be a positive bias with more cases occurring than would otherwise be expected, all other factors being equal. Discussions with Savannah River Laboratory personnel confirms that for these particular wind directions the air would have to first flow past the wind speed sensor before reaching the wind direction sensor. We now suspect that for these wind directions there is a distortion in the wind flow due to the orientation of the wind sensors.

4.1.5 Summary of surface parameter analyses

The surface roughness length was estimated to be 0.30 m using the longitudinal turbulence intensity. This value is reasonable considering the surface ground cover and the site description. This value of roughness length was used to develop estimates of the surface fluxes using the procedures outlined by Holtslag and Van Ulden (1982a,b). Specifying the constants in Equation (4-1) as A = 0.65 and B = W/m^2 resulted in L-values in accord with values obtained using Golder's (1972) procedures. Comparison

of the observed vertical and lateral turbulence intensities with theoretical estimates by Binkowski (1979) revealed no major inconsistencies. We did find a group of erroneous s_a values, having values below 2 degrees, that had gone undetected when the flagging procedures were developed. It was also found during these latter comparisons that the procedure employed for estimating L has a bias against estimating L-values of about 15 m. This is considered of minor consequence. An anomalous behavior in the turbulence values for westerly wind directions was traced to the wind shadow cast by the cup anemometer on the bivane for wind directions between 269 and 285 degrees.

4.2 Diurnal Variations

In the course of assessing the tower data for continuity and veracity, we found it useful to develop analyses of the diurnal variation of the meteorological elements. The typical solution is to average all data by hour of day. This was done for the Wangara data (Clarke, 1974) using the 40-day series of hourly observations to make an averaged value of each meteorological variable $a = a(t,z)$, where t is time of day and z height. The sharp changes in time and space are smeared by such a procedure. However, such averaged data are useful for a first assessment of the trends evident within a set of data.

For every other month starting with February, the 15-minute data values were grouped into 2 hour blocks, with 00-02 local standard time as the first block. About 240 cases were possible in each 2 hour block at each height, a total of 8 (four 15 minute periods per hour) times the number of days in the month. Missing and questionable data would reduce this number.

The values within each 2 hour group were sorted, lowest to highest, allowing definition of the percentile values of 2, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 98.

For the purpose of developing the diurnal patterns, the median values were used. Median values defined when less than 100 values were available within a data block were found to be erroneous in comparison to adjacent values in time and space. For plotting purposes undefined median values were estimated by linear interpolation between adjacent values in time. Occasionally, there were less than 100 values at several levels within the same plot.

Employing interpolation to estimate the median values was considered unsatisfactory; these plots were generated using dashed lines for the isopleths. Figures 4-11 through 4-35 depict the observed variations that occur in the median values by month and time of day. These plots were developed using an objective contour analysis employing the 7 by 12 array of median values, seven heights and twelve 2 hour blocks.

The meteorological variables summarized in these plots are potential temperature (C), wind speed (m/s), the standard deviation of the horizontal wind direction (degrees), the standard deviation of the vertical wind direction (degrees) and wind direction change (degrees). The wind direction change was defined by subtracting the value of the wind at 10 m from the values reported at the other heights.

The potential temperature, PT(t,z), was computed as,

$$PT(t,z) = T(t,z) + (g/c_p)z \qquad (4\text{-}4)$$

where T(t,z) is the temperature at time t and height z, g is the acceleration due to gravity and c_p is the specific heat capacity at constant pressure.

Equation (4-4) was used as pressure was not measured at the various tower levels. Equation (4-4) is valid only over a limited height range; typically application of (4-4) is limited to the lower 100 m of the atmosphere. Sample calculations using the standard atmospheric profiles for the mid-latitude suggest that (4-4) over a 300 m height range results in less than 1 percent error in specifying lapse rates. A defect in the procedure employed was that no provision was made for the daily variations in surface pressure that occur during a one month period. But this defect is negligible as even a 100 mb variation would result in less than a 3 percent variation in the computed potential temperatures.

The 10 m data were collected on a separate tower located approximately 80 m south of the main tower. A comparison of the 10-m data for consistency with the data collected on the main tower suggested no detectable bias in the wind speed or direction data, but there were some differences noted in the temperature data. These differences are possibly due to a difference in ground cover between the two sites. A estimate of the bias was developed from an analysis of superadiabatic lapse rates between the 10 and 36 m levels during nighttime and inversions between the 10 and 36 m levels during the daytime. The average temperature correction was estimated by jointly minimizing the occurrence of these events. Table 4-6 reports the estimated corrections computed for each month for the 1976 data. These corrections were applied to the 10 m temperatures in all succeeding analyses.

In addition to the plots which depict the diurnal variation in the median values, Tables 4-7 through 4-10 list for selected heights and times during the day the 90-th, 50-th and 10-th percentile values, for a winter

and a summer month. These listings allow assessment of the range of values possible and how these ranges vary by season and time of day.

As mentioned in Section 1.2, studies of tower effects on wind measurements suggest that the tower would affect wind direction measurements in the 50° sector from 355 to 45°. The instruments on the 10-m tower were mounted so as not to be affected by the 10-m tower. However, the nearness of the 10-m tower to the TV-tower and the associated building (Figure 2-7) suggest that the wind direction measurements on the 10-m tower may be affected for the 60° sector from 330 to 30°. For the analysis of the standard deviation of the horizontal wind direction fluctuations for the month of June, there were 1190 cases of the original 17,210 cases possibly affected by building or tower effects. This represents just less than 7% of the data. These numbers are typical for the other analyses and months. The small number of cases affected, most likely accounts for the negligible change observed in the median values when these cases are excluded. The changes to the 90-th and 10-th percentile values were small but noticeable when these cases were excluded. The percentile values presented in the tables were developed excluding cases possibly affected by tower, instrument display or building effects. Exclusion of these cases seemed appropriate as the 10-th and 90-th percentile values are presented. The figures of the diurnal patterns were generated before the possibility of building or tower effects had been included in the analysis. Considering the negligible effect observed in the median values, it was not considered worthwhile to redo the figures, excluding the few cases possibly affected.

In general, these tables and plots reveal the expected annual trends in the diurnal patterns. The structure on any given day would differ in

detail. And variations certainly occur in the depicted patterns from one year to the next. Hence, we warn against placing too much emphasis on the precise details in the patterns or in the precise magnitudes of the variables. The value of these table and plots, we believe, is in developing a sense of the seasonal trends that occur in the structure and gradients in time and space. One can also develop some sense of the typical magnitudes to be expected.

4.3 Seasonal Variations

After inspecting a number of the diurnal patterns for each month for each meteorological variable, characteristic (key) features of these patterns were chosen for analysis over the 5-year period. As a working criteria in the selection of these features, those qualities were selected that, if properly approximated, would strongly promote an accurate description of the observed diurnal patterns for each month.

As an example, consider the potential temperature patterns in Figure 4-11. The potential temperature is nearly constant within the well-mixed layer in the afternoon. To a first order approximation, knowing the maximum 10 m temperature and time of occurrence, the afternoon temperature profile can be defined. The surface based temperature inversion in the early morning hours was consistently strongest when the 10 m temperature was at a minimum. Knowing the inversion strength, the minimum 10 m temperature, and the time of occurrence provided a definition of the early morning vertical temperature profile. To approximate the diurnal course of the temperature, a linear interpolation in time can be used between these two simplified representations of the temperature profiles when the 10-m temperature is at

a minimum and maximum. Hence, the monthly diurnal patterns of potential temperature can be described in terms of three qualities: the magnitude and timing of the 10-m maximum and minimum temperatures, and the strength of the temperature inversion over the lower 300 m at the time when the surface minimum temperature occurs. A similar line of reasoning can be applied for each of the meteorological variables.

Table 4-11 lists the key features selected for analysis for each of the meteorological variables. The values determined for these key features are listed in Tables 4-12 through 4-19.

An inspection of the time series of values determined suggested strong seasonal dependence for some of the key features. A procedure was established for determining a best fit sine-wave to the key feature values as an aid in assessing the seasonal dependence. The period was assumed to be one year. The general equation has the form,

$$y(t) = a + b \sin (ct + d) + e(t) \qquad (4\text{-}5)$$

where y is the key feature value, t is the month number (January 1975 = 1; December 1979 = 60), c is the period (fixed at $\pi/6$), and e is a random variable of mean zero. The values a, b, and d were found such that the sum of the deviations squared (sum of e^2 over all values) was a minimum. Given a and d, it can be shown that b can then be determined as,

$$b = [\sum (y-a) \sin (ct + d)]/[\sum \sin^2(ct + d)].$$

The best fit value for the phase, d, was determined iteratively, a is the mean value and b is the amplitude. As there was only one time series available for estimating parameters, a jacknife procedure was used to determine confidence limits on the best fit estimates for a and b.

As an alternative to the model provided by Equation (4-5), one could hypothesize that there exist no significant seasonal trends. In such cases, the y values might be modeled as,

$$y(t) = \bar{y} + e(t) \qquad (4\text{-}6)$$

where $\bar{y}$ is the average. An F-test can be used to test whether the variance is significantly reduced is using Equation (4-5) over that obtained using Equation (4-6).

Table 4-20 lists the curve fitting results for those key features for which the F-test suggested seasonal dependence was significant. Table 4-21 lists the relevant statistics for the other key features. The results presented in Table 4-21 suggest that the timing, when events occur, such as the 10-m maximum temperature, was fairly consistent.

Figure 4-36 depicts the results obtained for the nocturnal wind speed maximum and the nighttime inversion strength. The dashed lines in the figure are the model of the observations provided by equation (4-5) with the constants given in Table 4-20. Whether the seasonal variation depicted for the inversion results is significant is questionable, as noted in Table 4-20. Figure 4-37 depicts the results obtained for the 10-m values of maximum wind speed and maximum temperature.

The F-test results, comparing the above two models, equations 4-5 and 4-6, suggest that seasonal variations can be detected and characterized. Those key features shown to have a significant seasonal variation within the tower data, provide a standard for comparison in model evaluation studies. For instance, if boundary layer meteorology were simulated using routinely available National Weather Service data, comparison could be made to determine how well the simulated meteorology describe the determined

seasonal variations. Objective statements could be made whether the simulated meteorology provided as precise a characterization of the variations as that determined with the available tower data.

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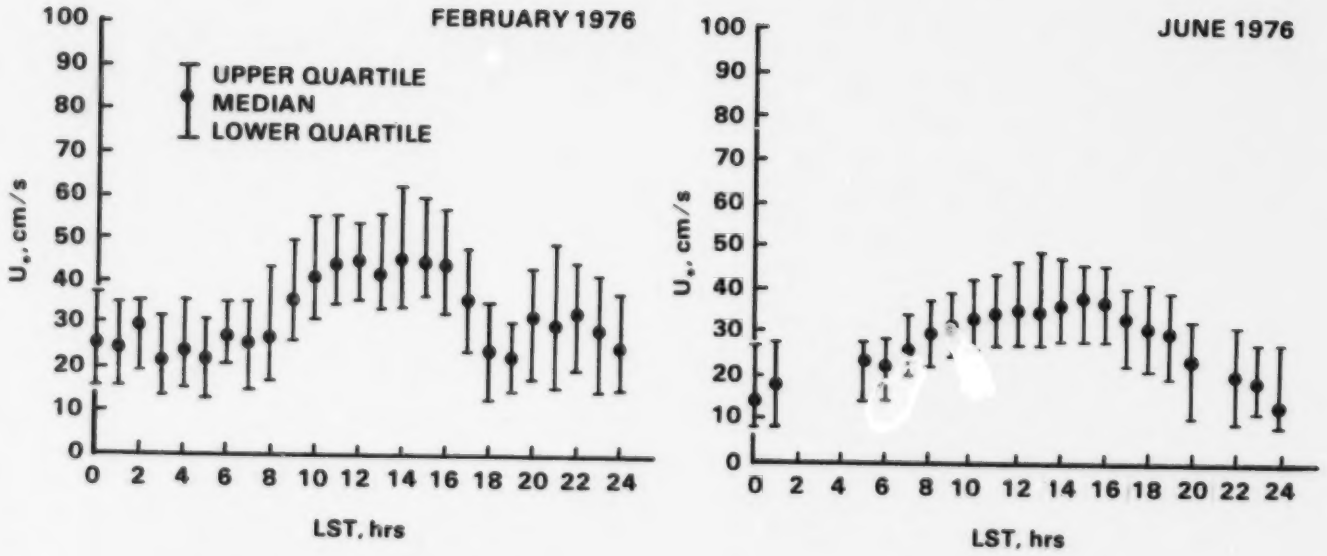

Figure 4-1. Summary of surface fiction velocity, u_*, estimates for February and June 1976.

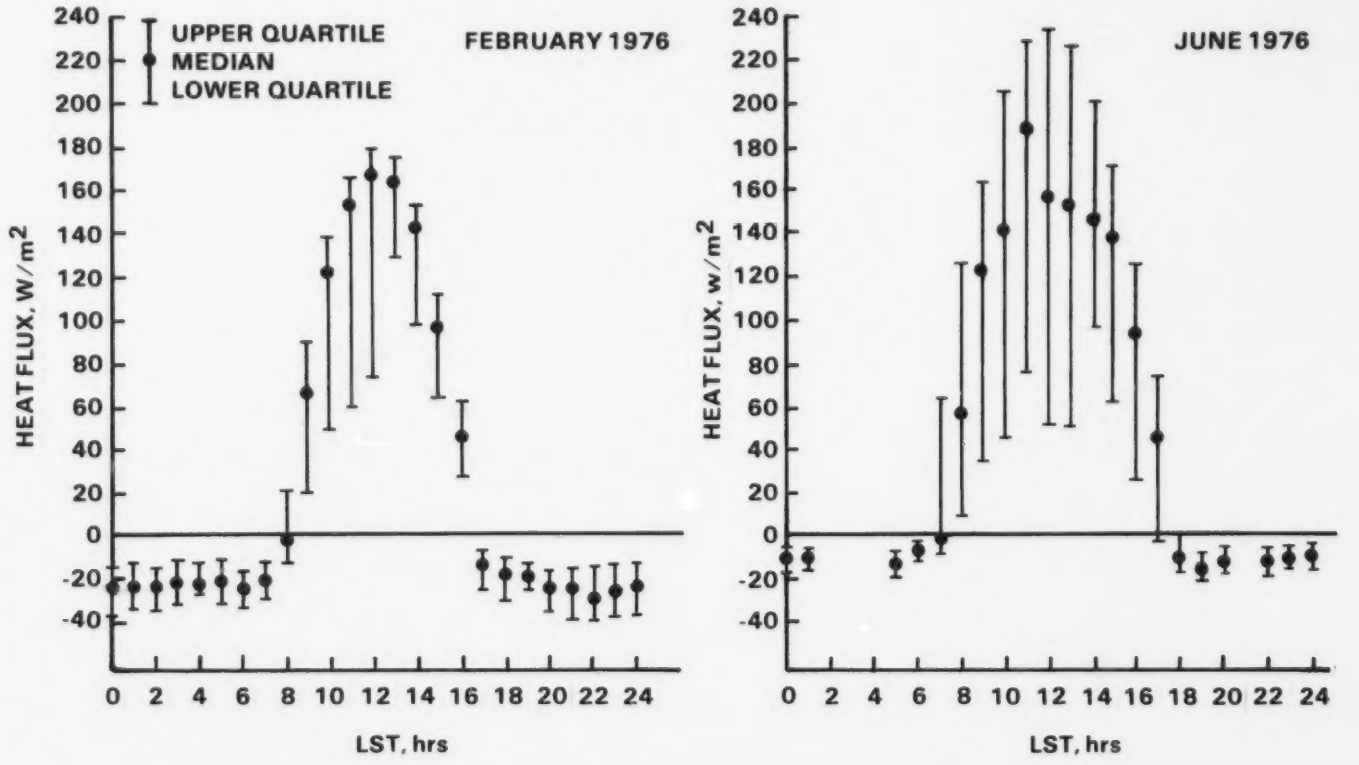

Figure 4-2. Summary of heat flux, H, estimates for February and June 1976.

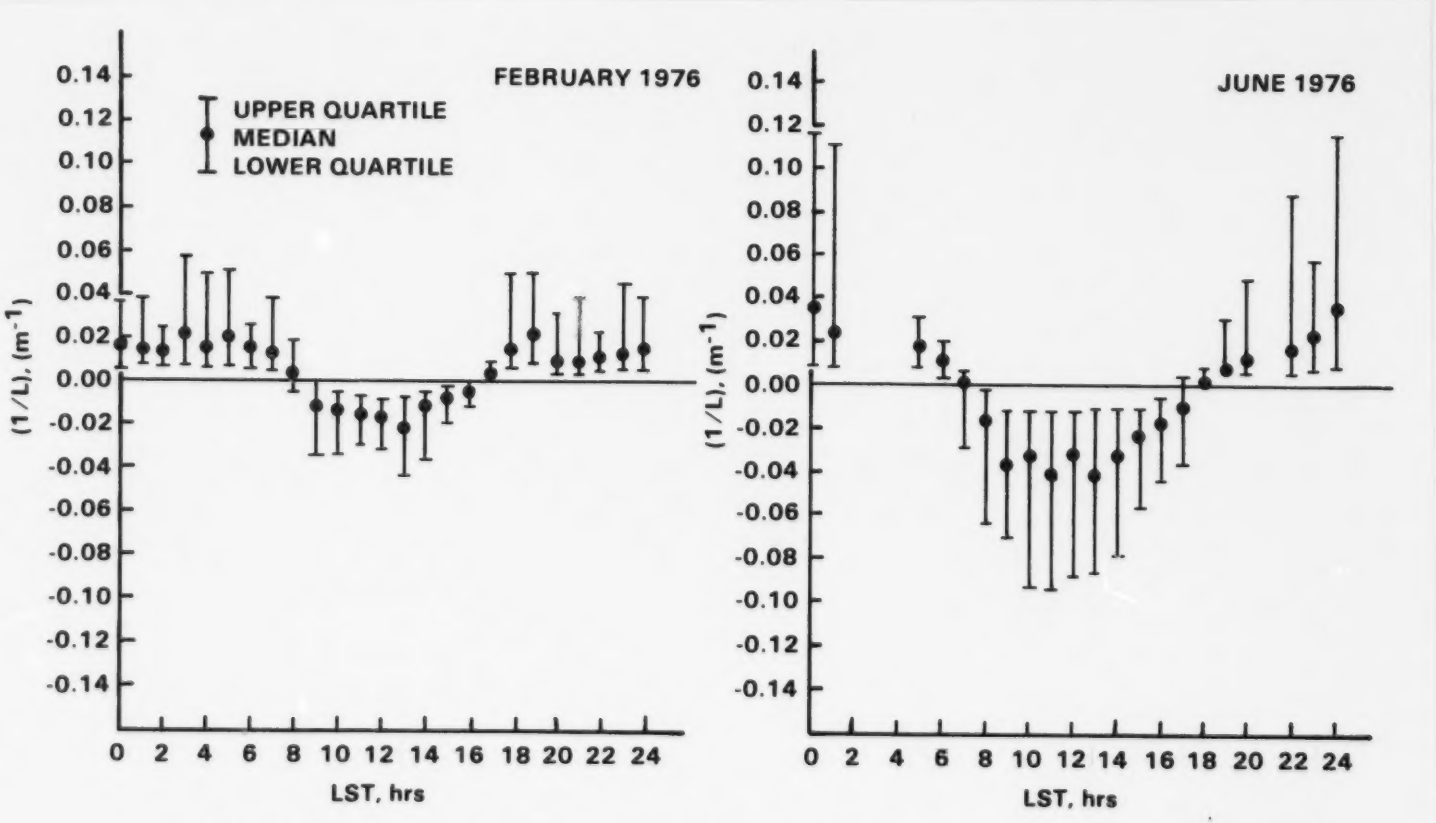

Figure 4-3. Summary of Monin-Obukhov length, L, estimates for February and June 1976.

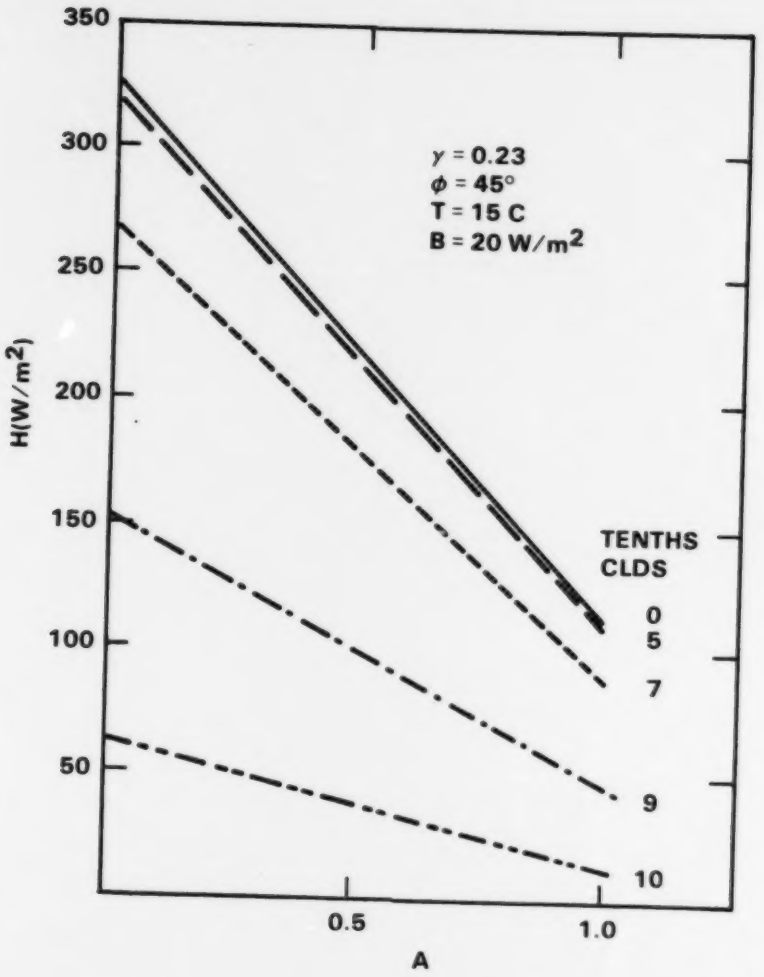

Figure 4-4. Variation of heat flux, H, estimates as a function of cloud cover amount and choice of constant A in Equation 4-1.

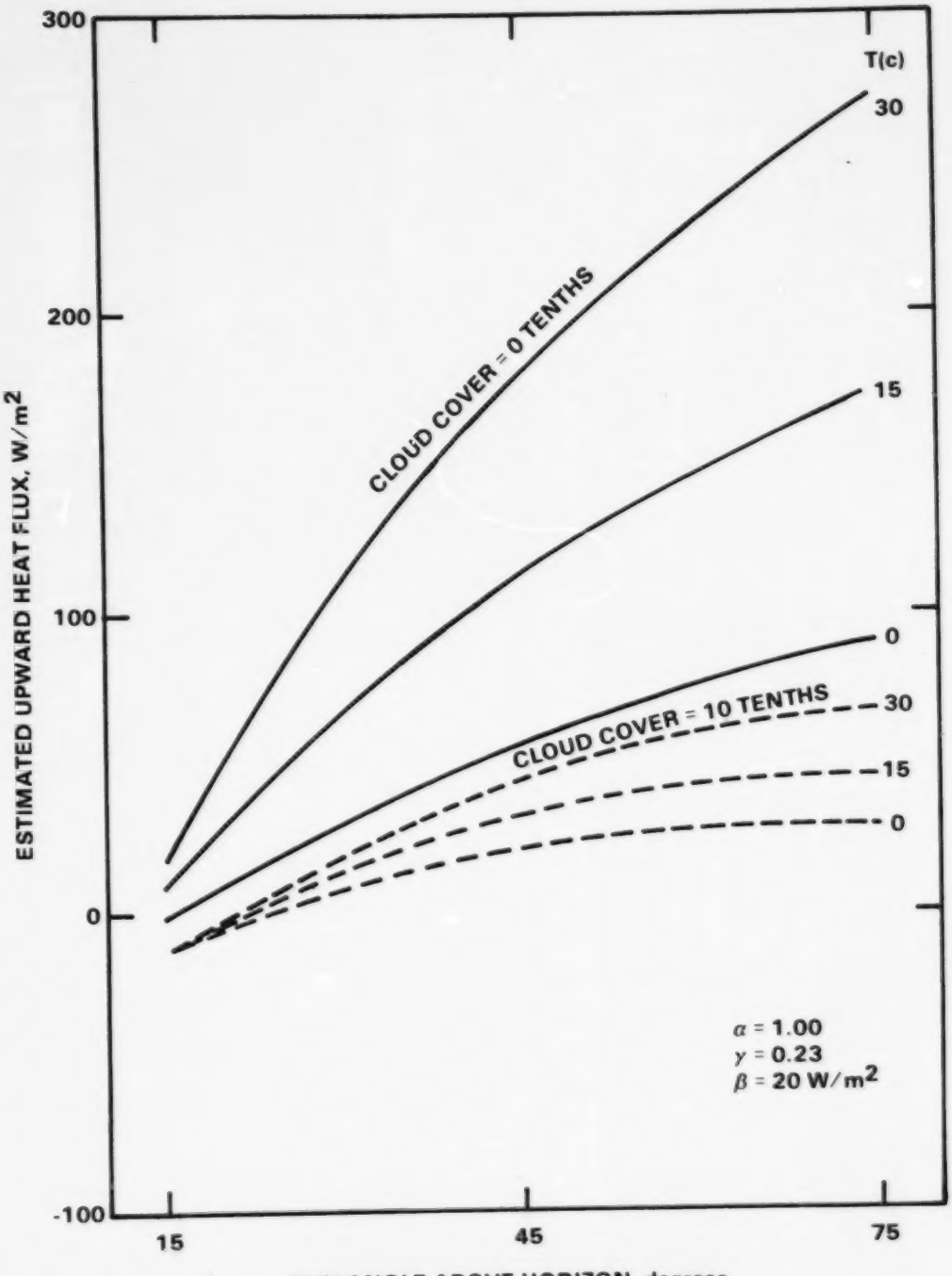

Figure 4-5. Variation of heat flux, H, estimates as a function of ambient temperature, T, and angle of sun above the horizon, for cloud cover amounts of 0 and 10 tenths.

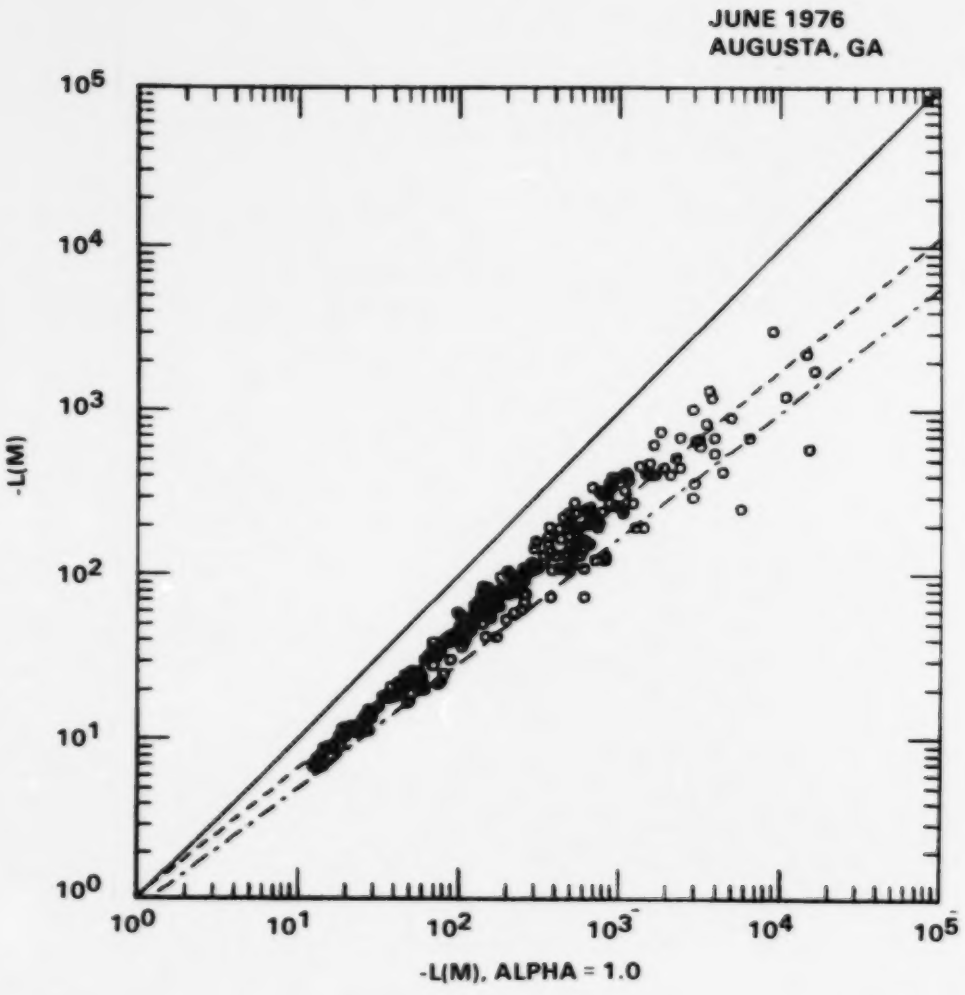

Figure 4-6. Comparison of Monin-Obukhov length values estimated with A = 0.65 versus results obtained with A = 1.0. Dashed line is least squares fit to values plotted. Dash-dot line is least squares fit obtained for results with A = 0.30.

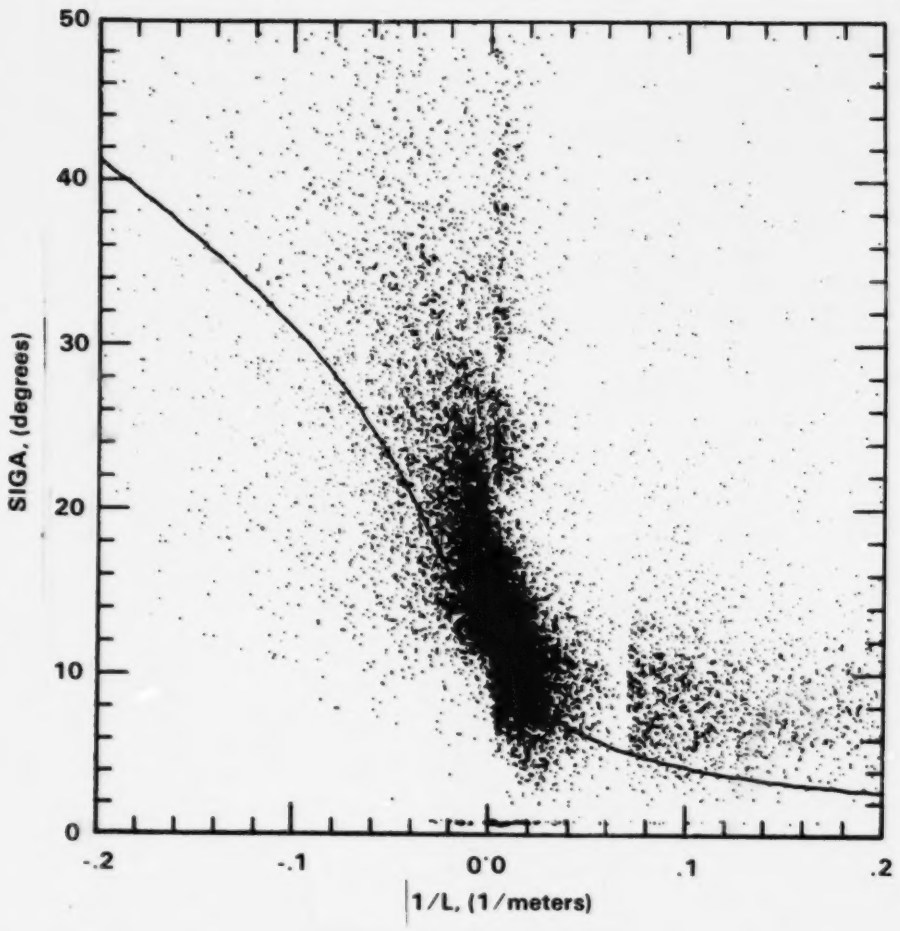

Figure 4-7. Scatter plot of observed 10-m values of the standard deviation of the horizontal wind direction, Sa, as a function of Monin-Obukhov length, L. See discussion in section 4.1.4.

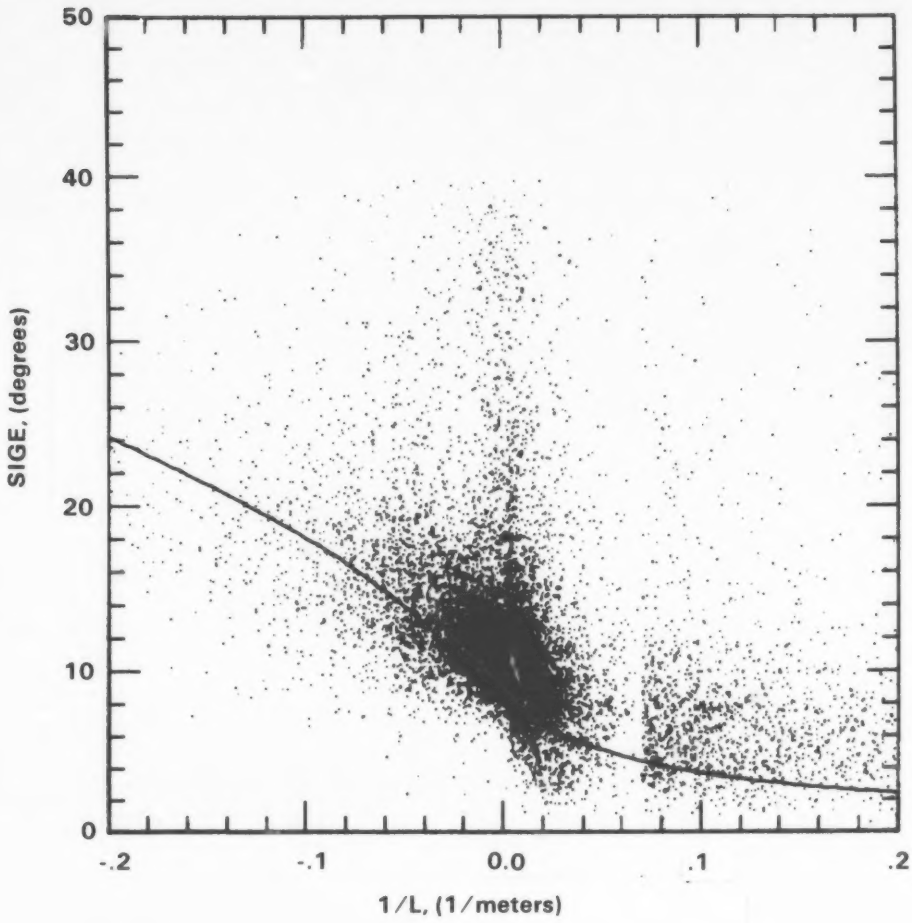

Figure 4.8. Scatter plot of observed 10-m values of the standard deviation of the vertical wind direction, Se, as a function of Monin-Obukhov length, L. See discussion in section 4.1.4.

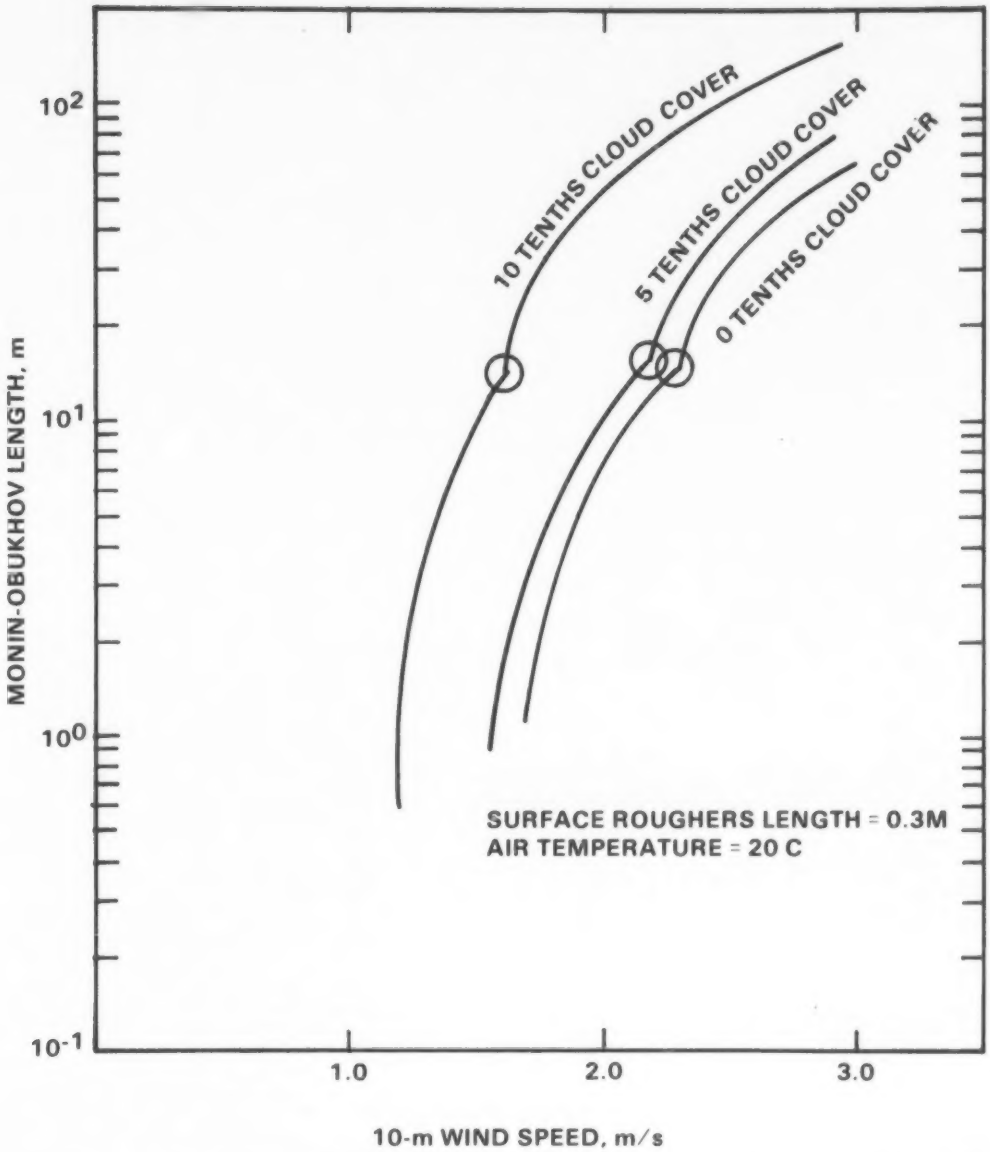

Figure 4-9. Variation of Monin-Obukhov length, L, estimates versus 10-m wind speed for cloud cover amounts of 0, 5 and 10 tenths.

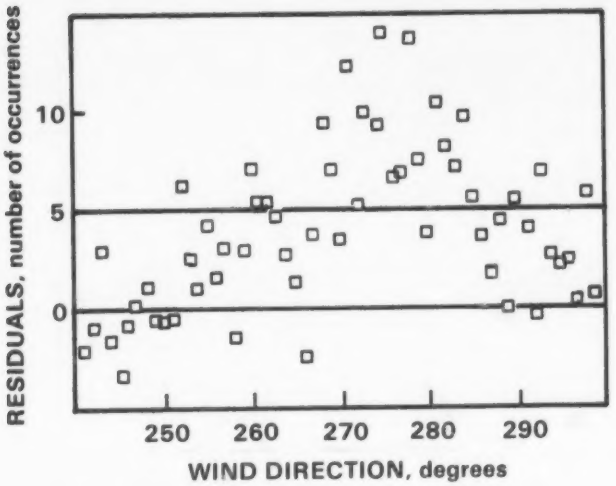

Figure 4-10. Residual number of occurrences, observed minus projected number of cases, of s_a values greater than 25 degrees for wind directions from between 240 and 300 degrees.

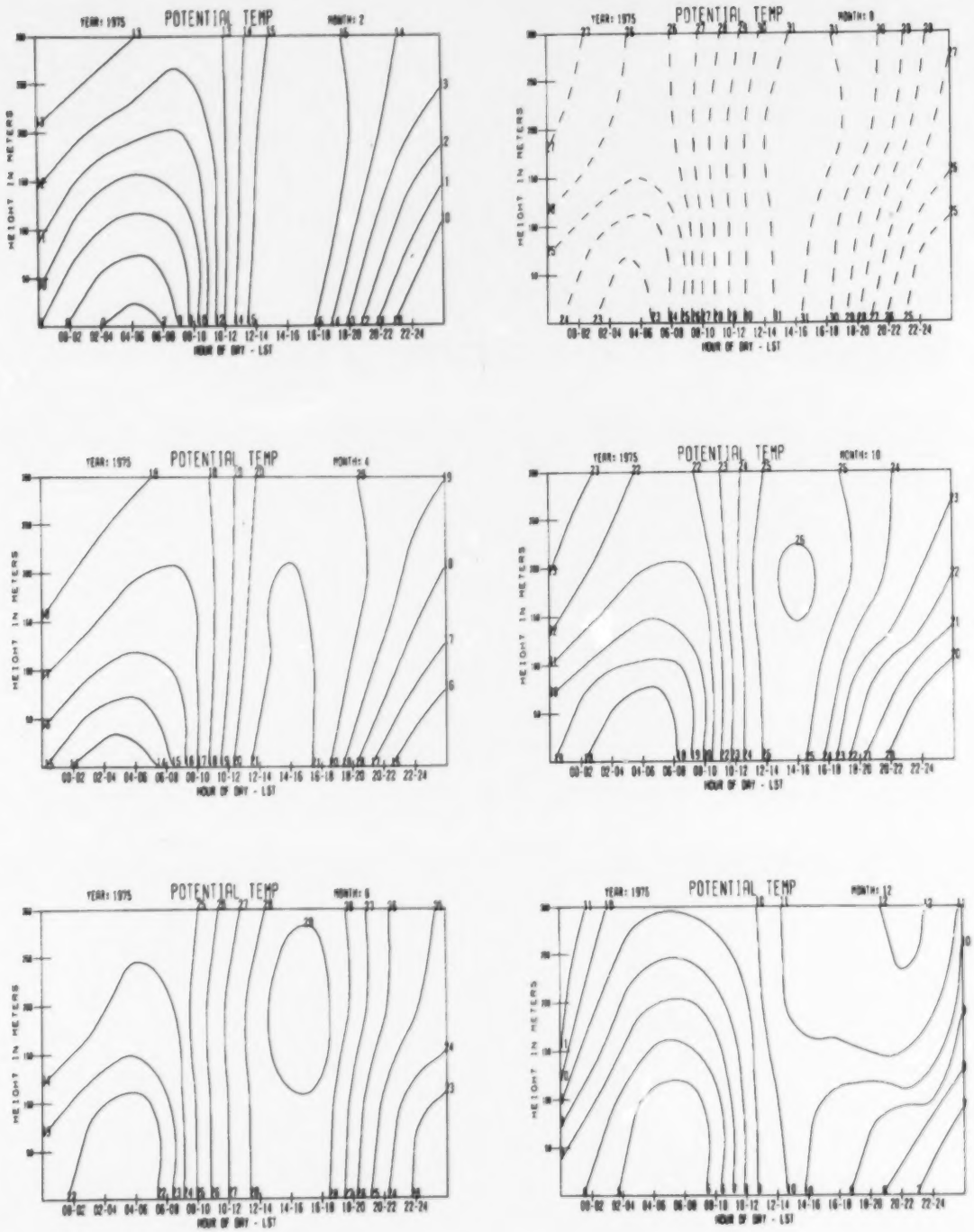

Figure 4-11. Observed monthly patterns of the diurnal course of the potential temperature for 1975.

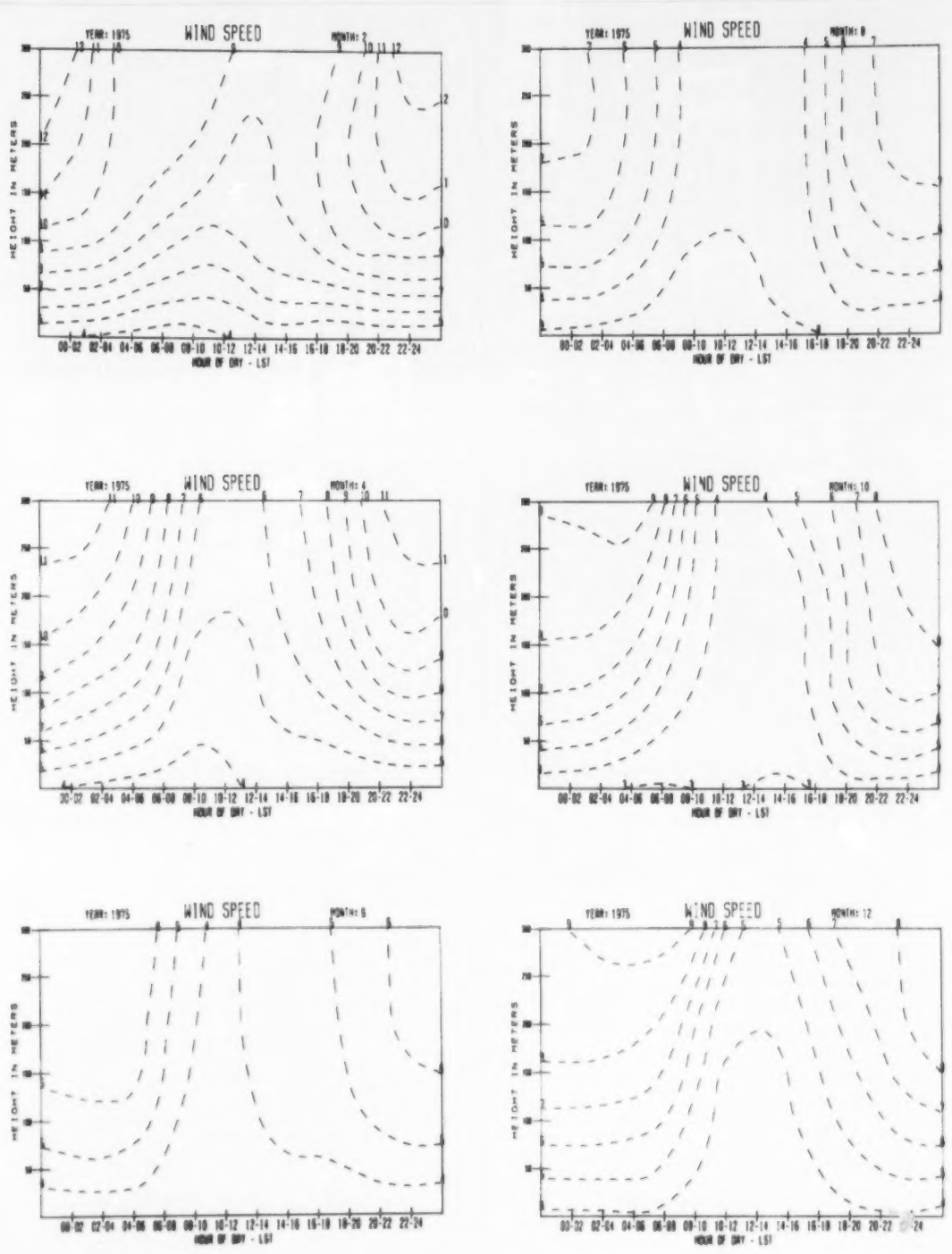

Figure 4-12. Observed monthly patterns of the diurnal course of the wind speed for 1975.

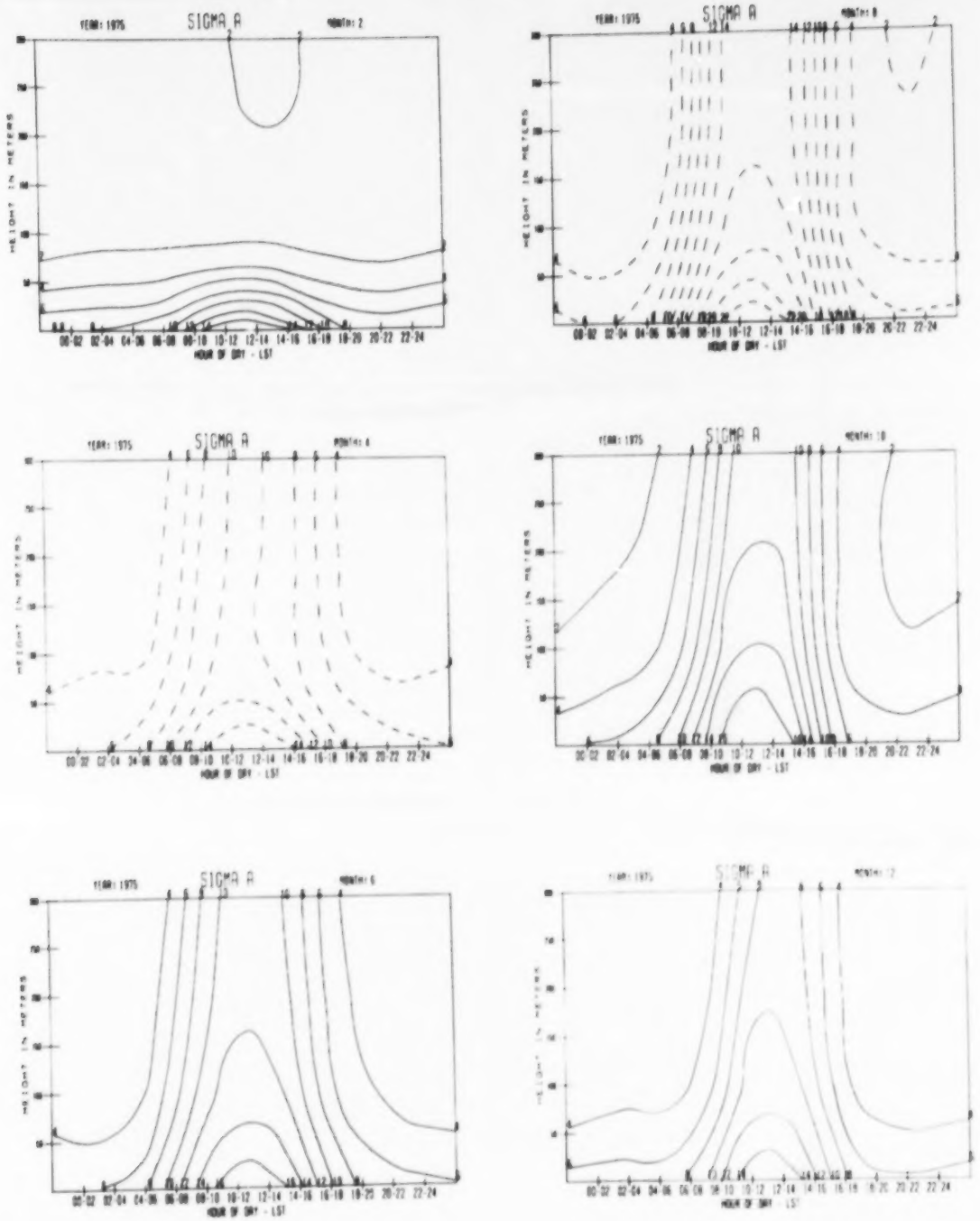

Figure 4-13. Observed monthly patterns of the diurnal course of the standard deviation of the horizontal wind direction for 1975.

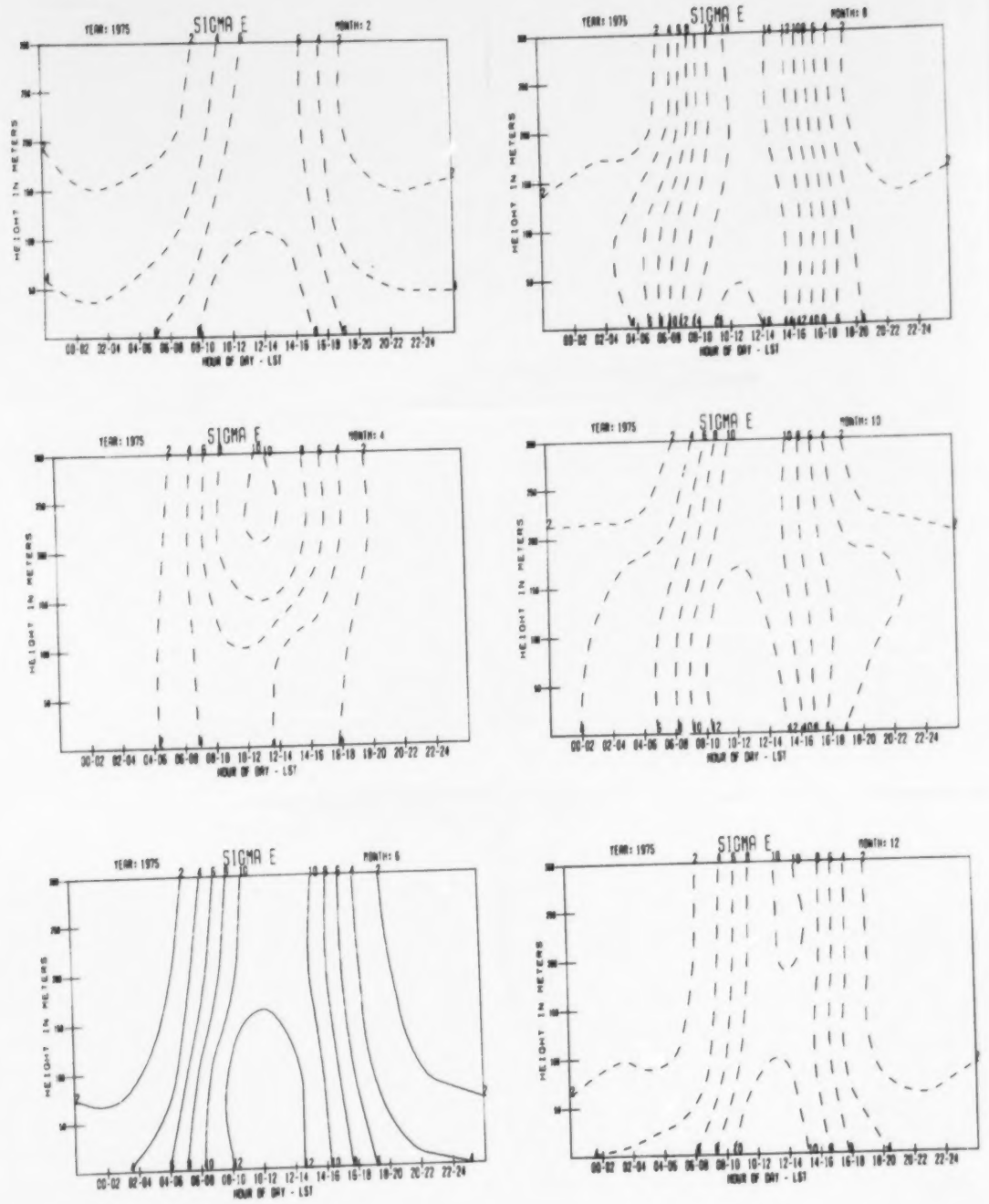

Figure 4-14. Observed monthly patterns of the diurnal course of the standard deviation of the vertical wind direction for 1975.

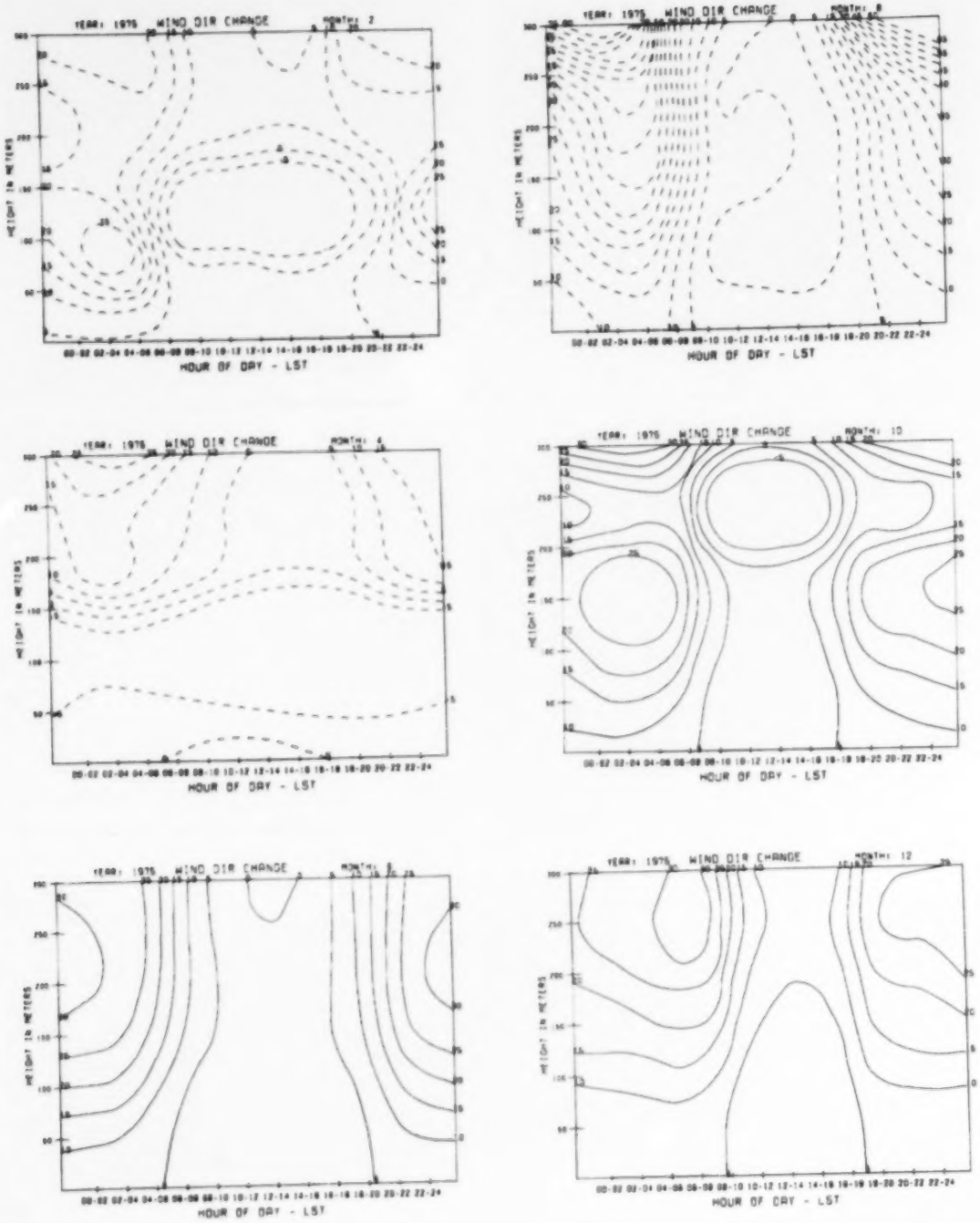

Figure 4-15. Observed monthly patterns of the diurnal course of the wind direction change with height for 1975.

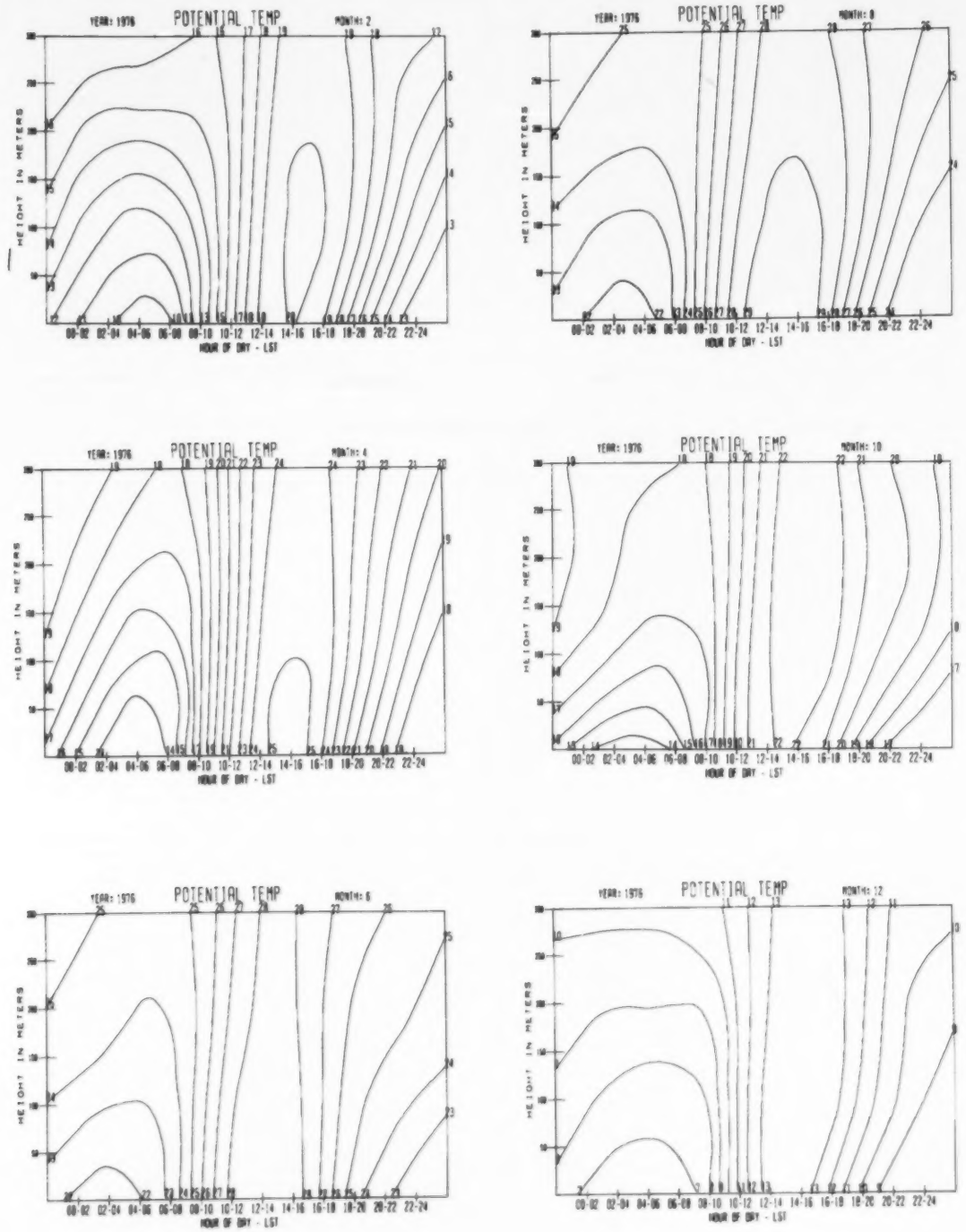

Figure 4-16. Observed monthly patterns of the diurnal course of the potential temperature for 1976.

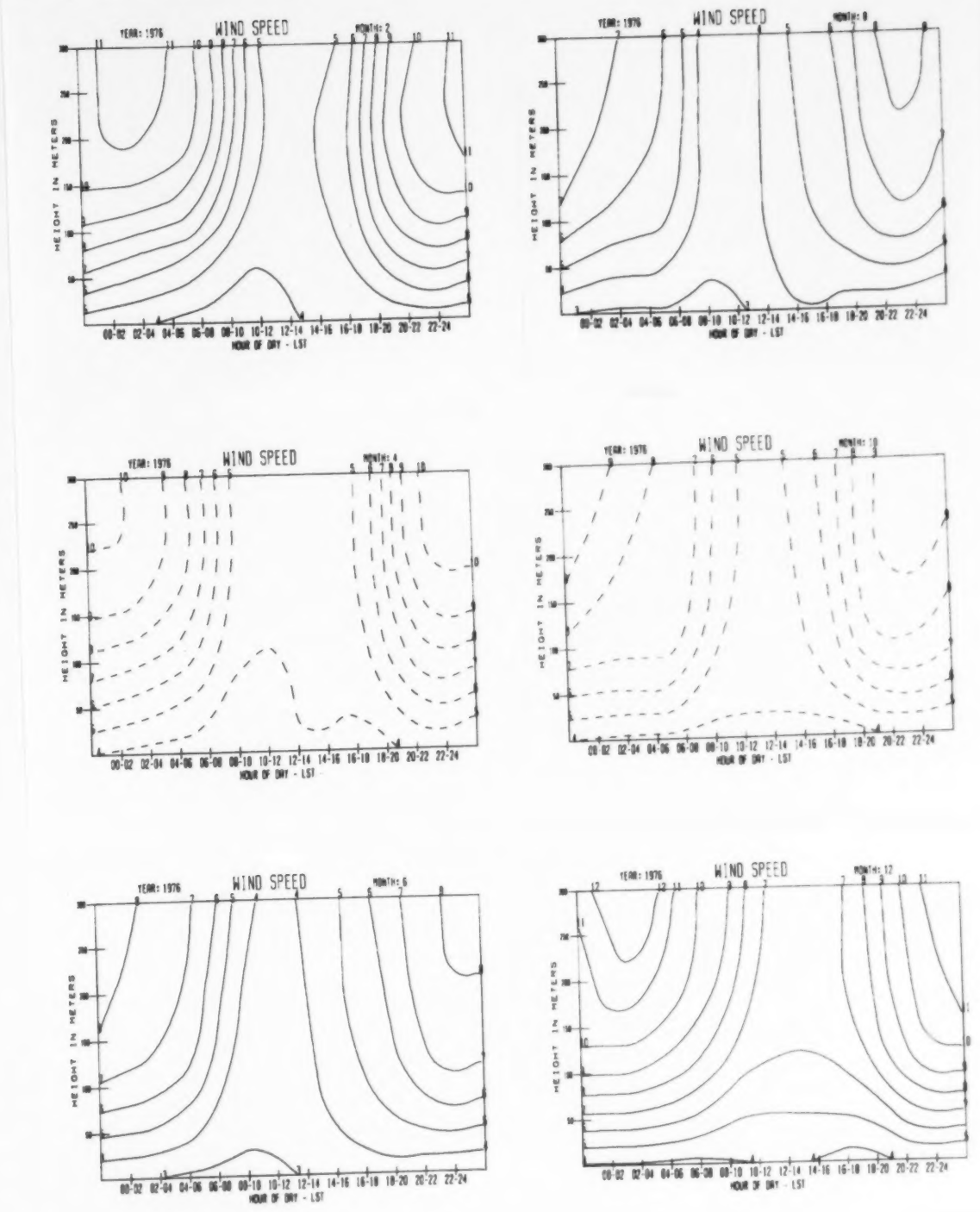

Figure 4-17. Observed monthly patterns of the diurnal course of the wind speed for 1976.

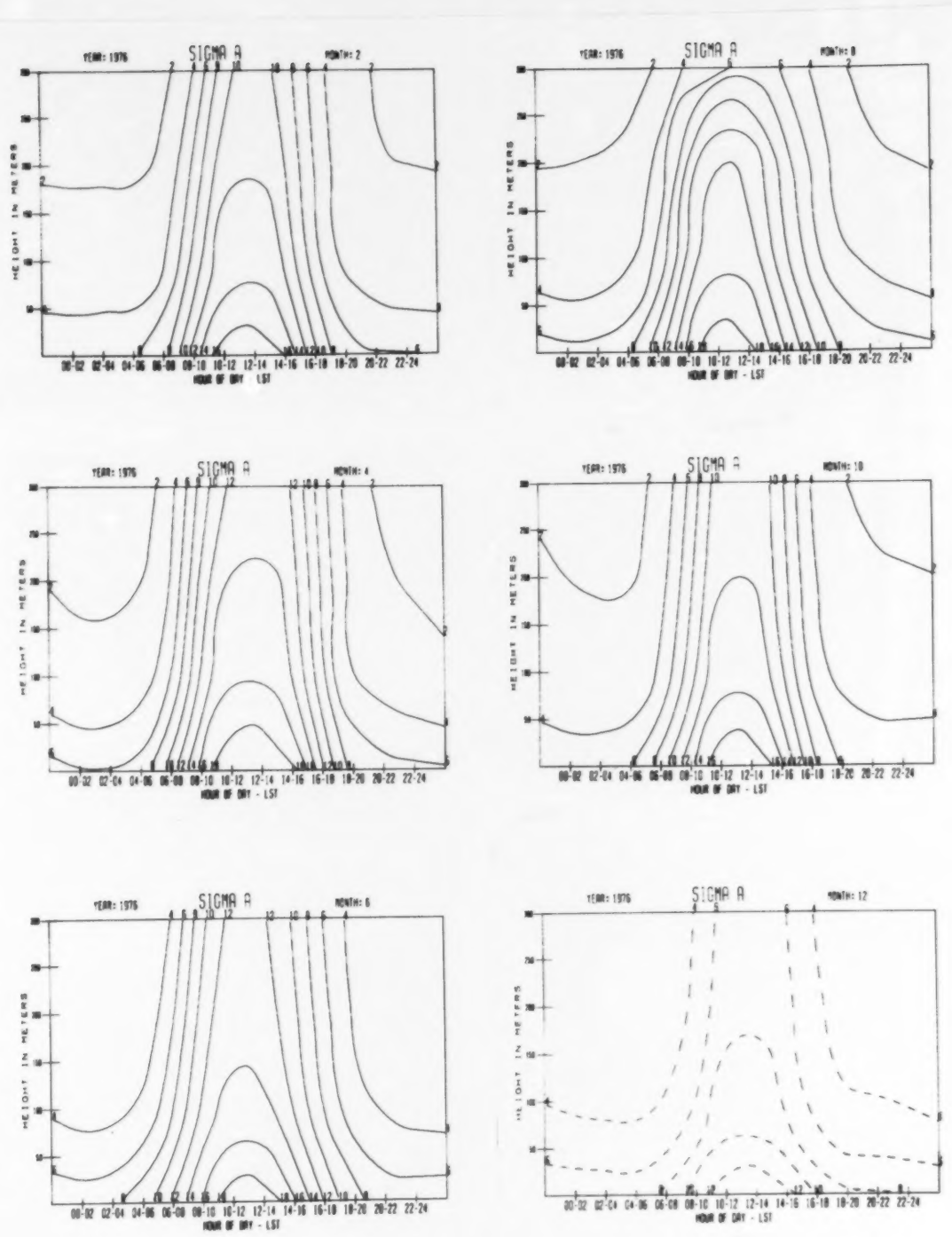

Figure 4-18. Observed monthly patterns of the diurnal course of the standard deviation of the horizontal wind direction for 1976.

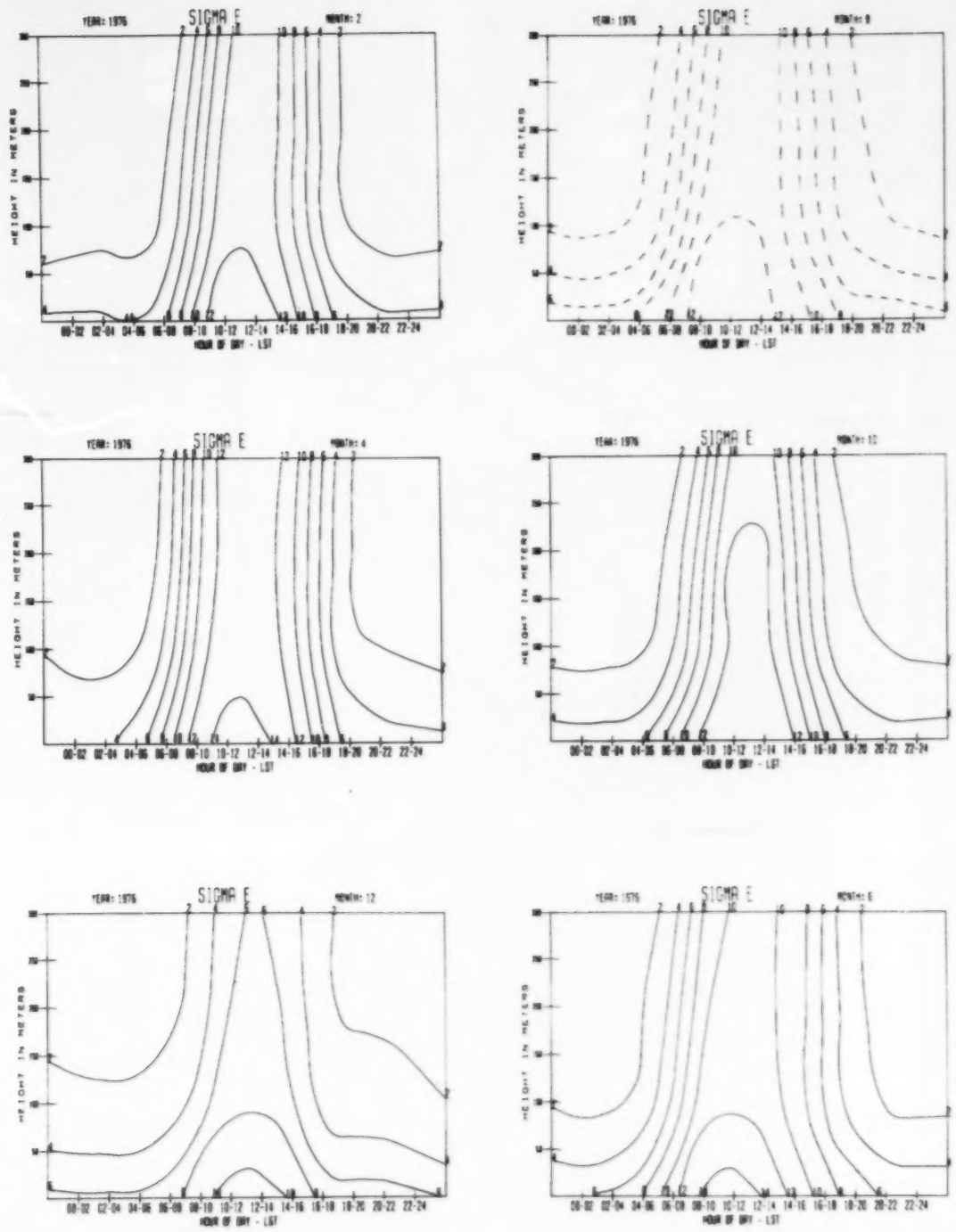

Figure 4-19. Observed monthly patterns of the diurnal course of the standard deviation of the vertical wind direction for 1976.

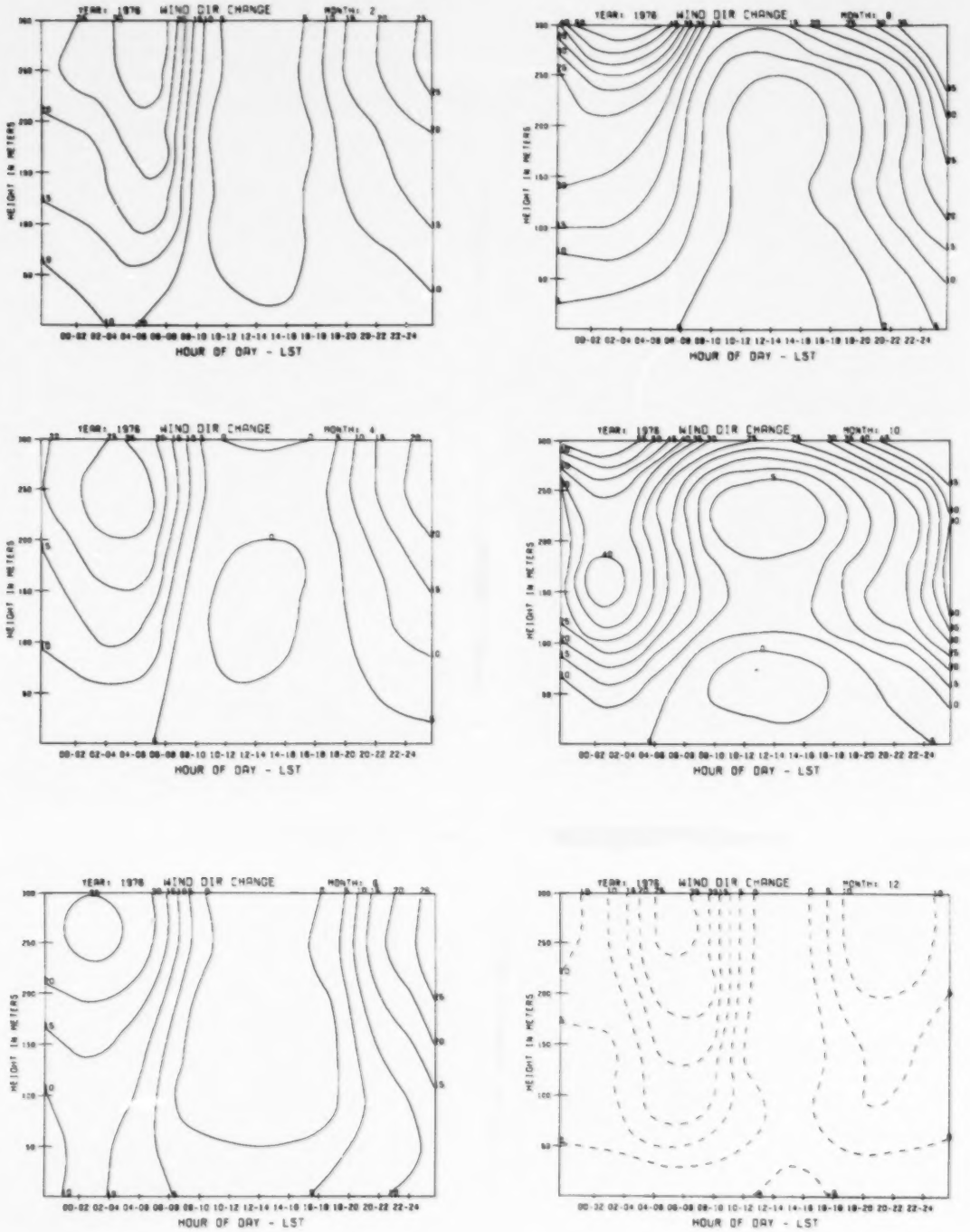
YEAR: 1976 WIND DIR CHANGE MONTH: 2
YEAR: 1976 WIND DIR CHANGE MONTH: 8
YEAR: 1976 WIND DIR CHANGE MONTH: 4
YEAR: 1976 WIND DIR CHANGE MONTH: 10
YEAR: 1976 WIND DIR CHANGE MONTH: 6
YEAR: 1976 WIND DIR CHANGE MONTH: 12
HEIGHT IN METERS
HOUR OF DAY - LST

Figure 4-20. Observed monthly patterns of the diurnal course of the wind direction change with height for 1976.

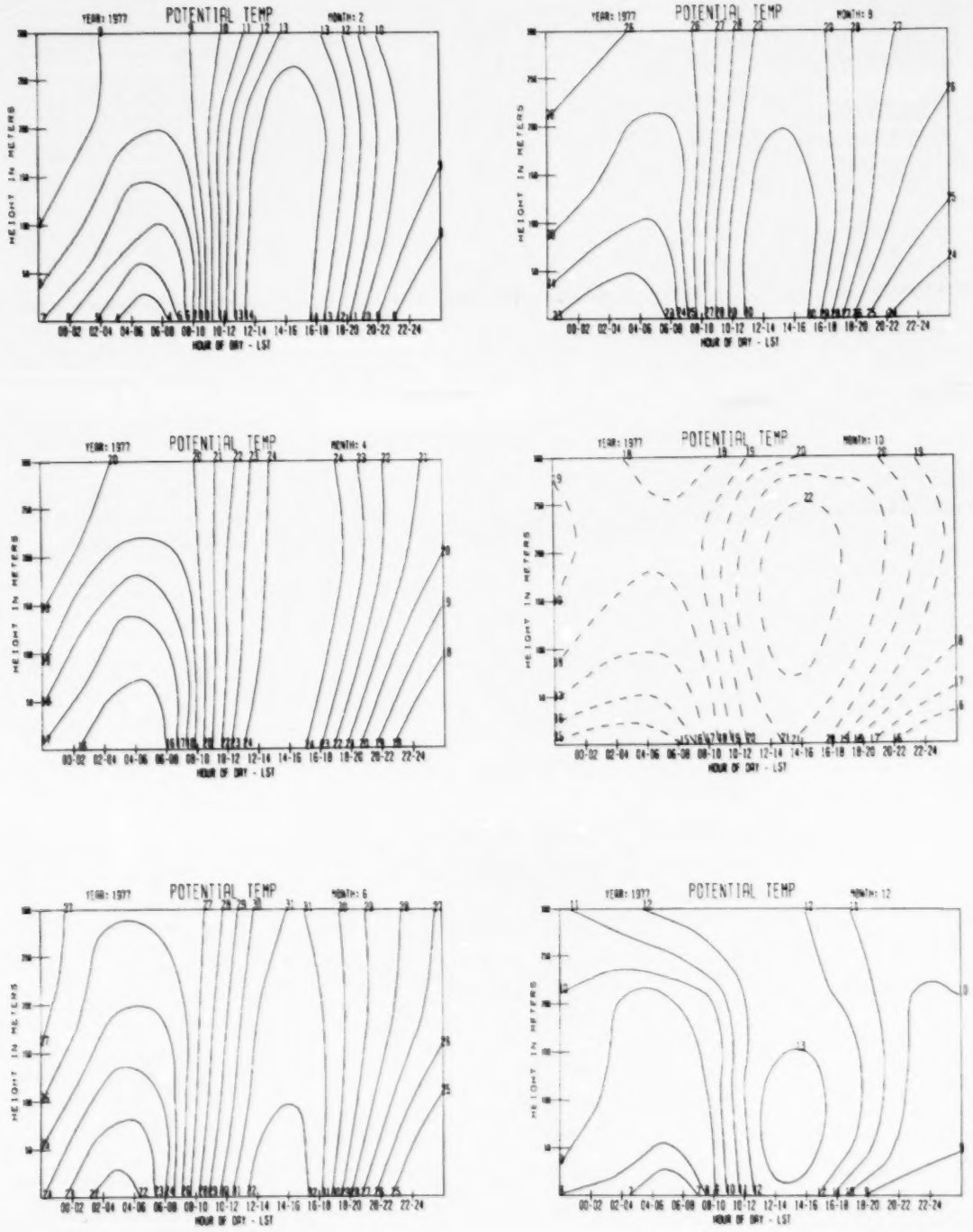

Figure 4-21. Observed monthly patterns of the diurnal course of the potential temperature for 1977.

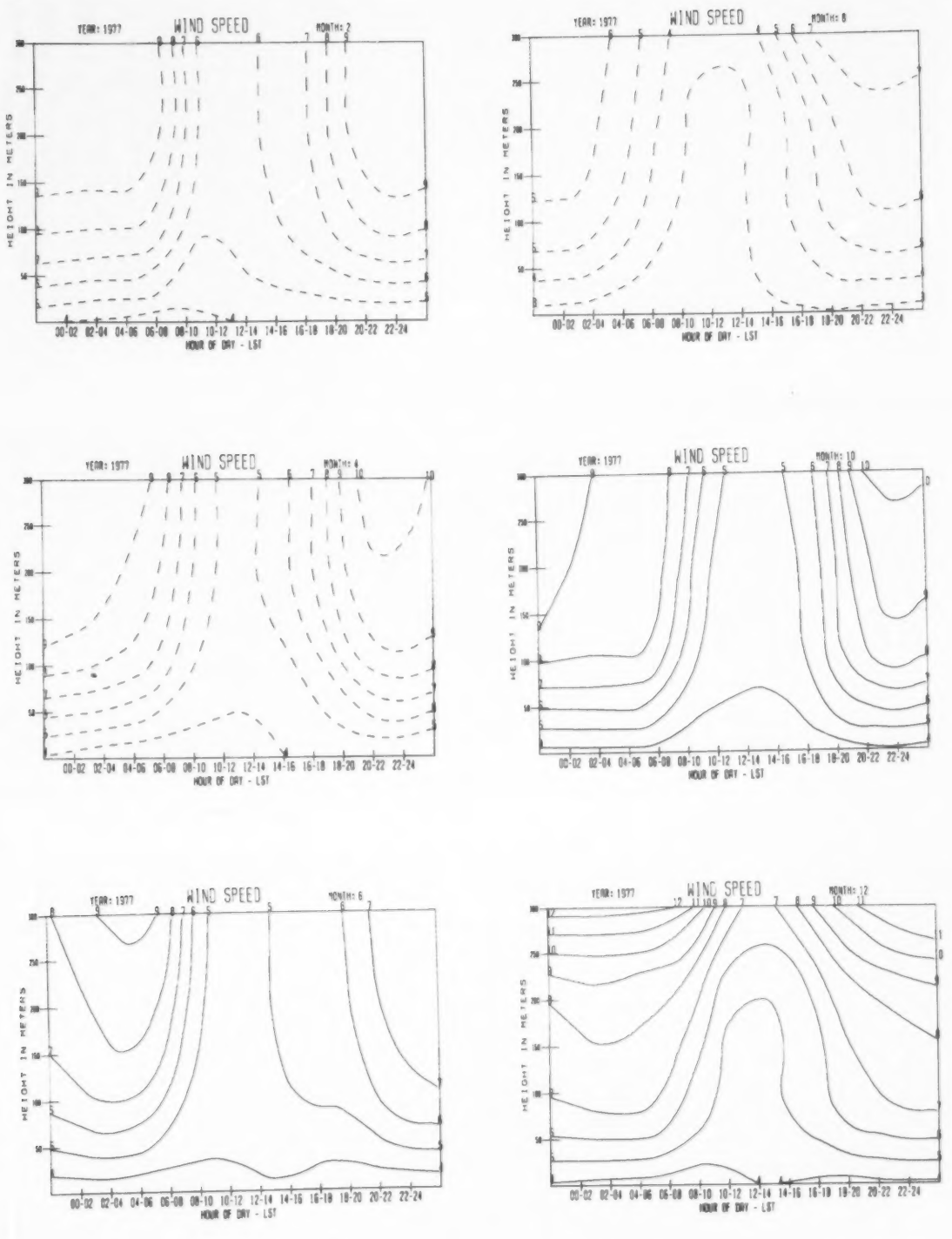

Figure 4-22. Observed monthly patterns of the diurnal course of the wind speed for 1977.

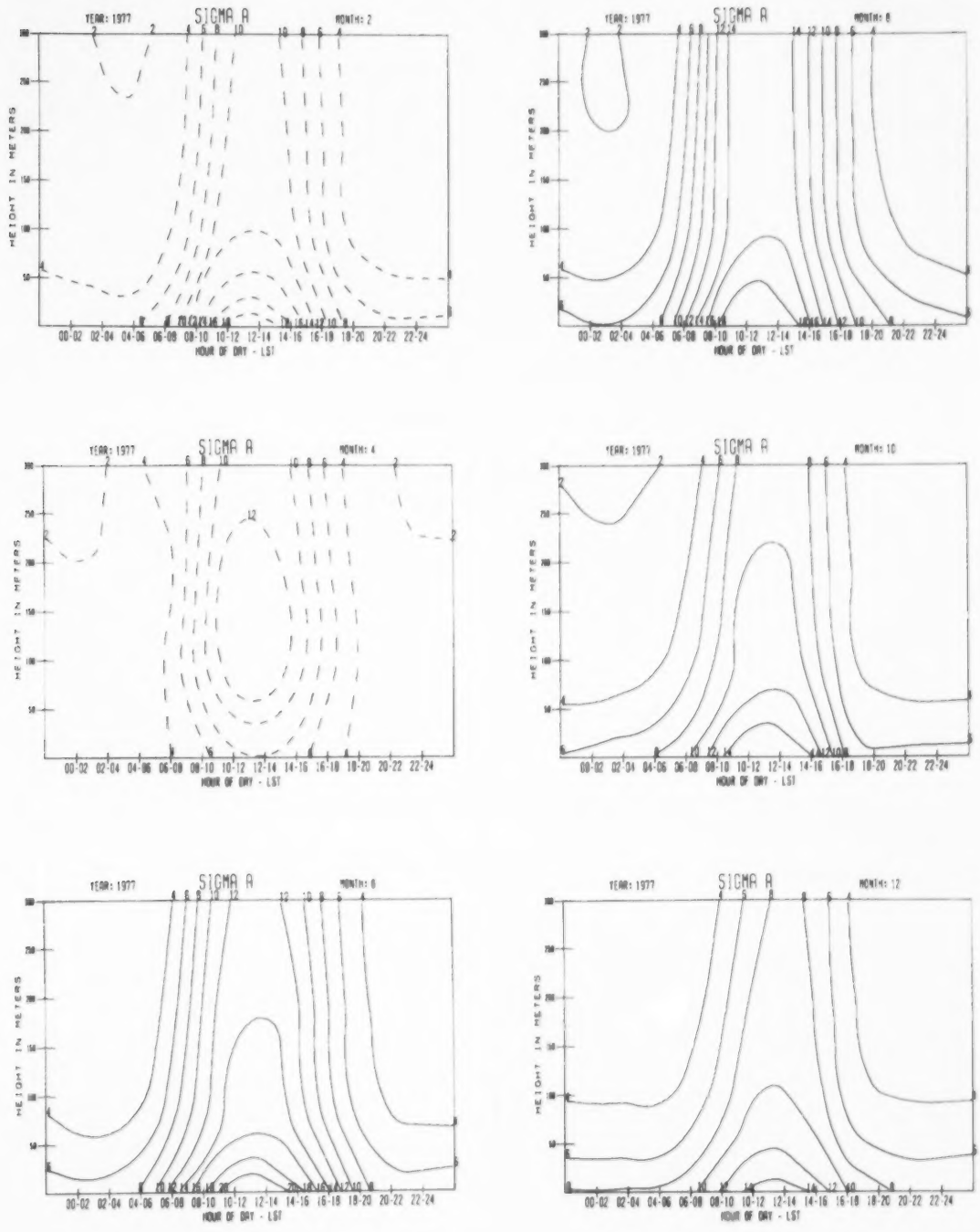

Figure 4-23. Observed monthly patterns of the diurnal course of the standard deviation of the horizontal wind direction for 1977.

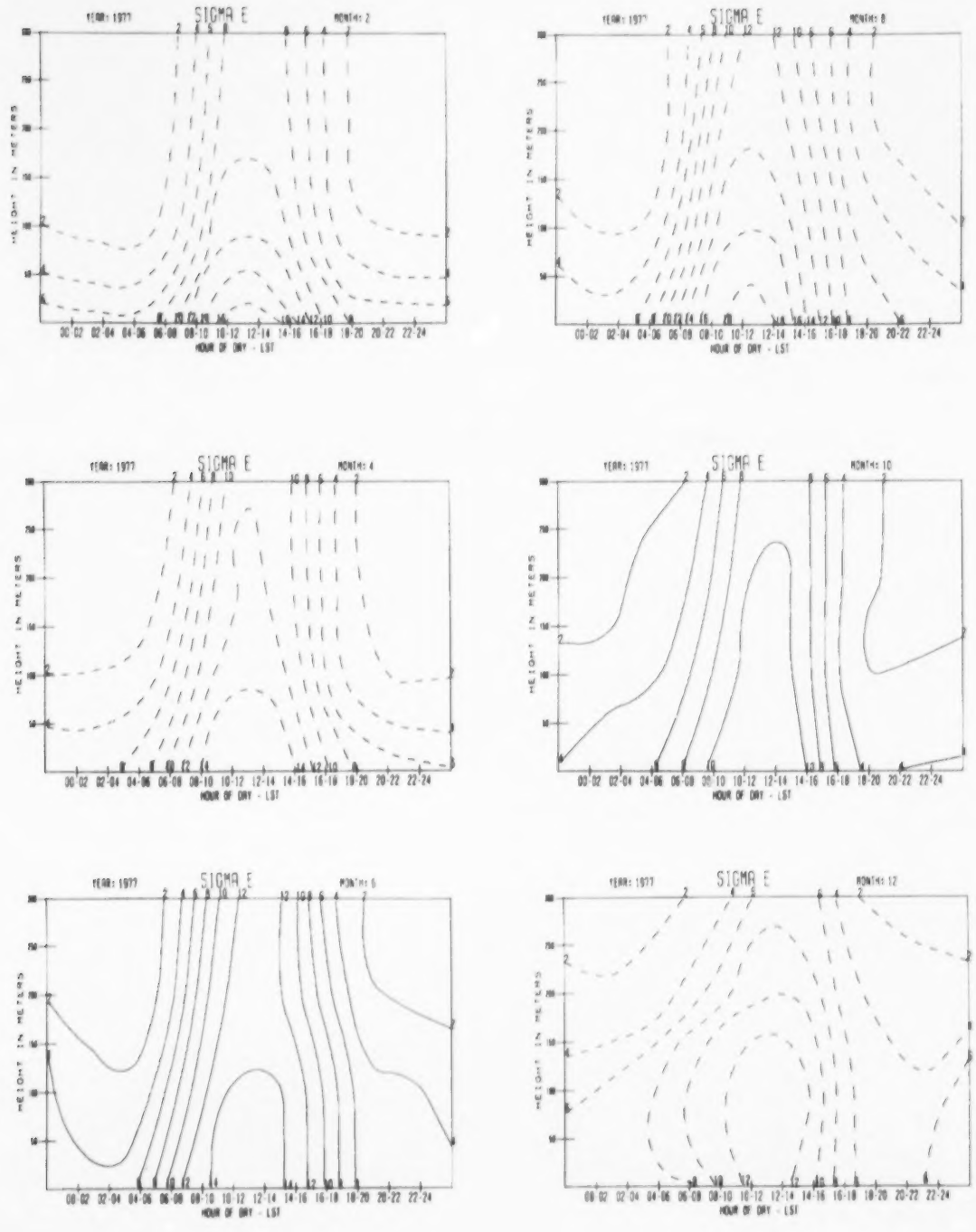

Figure 4-24. Observed monthly patterns of the diurnal course of the standard deviation of the vertical wind direction for 1977.

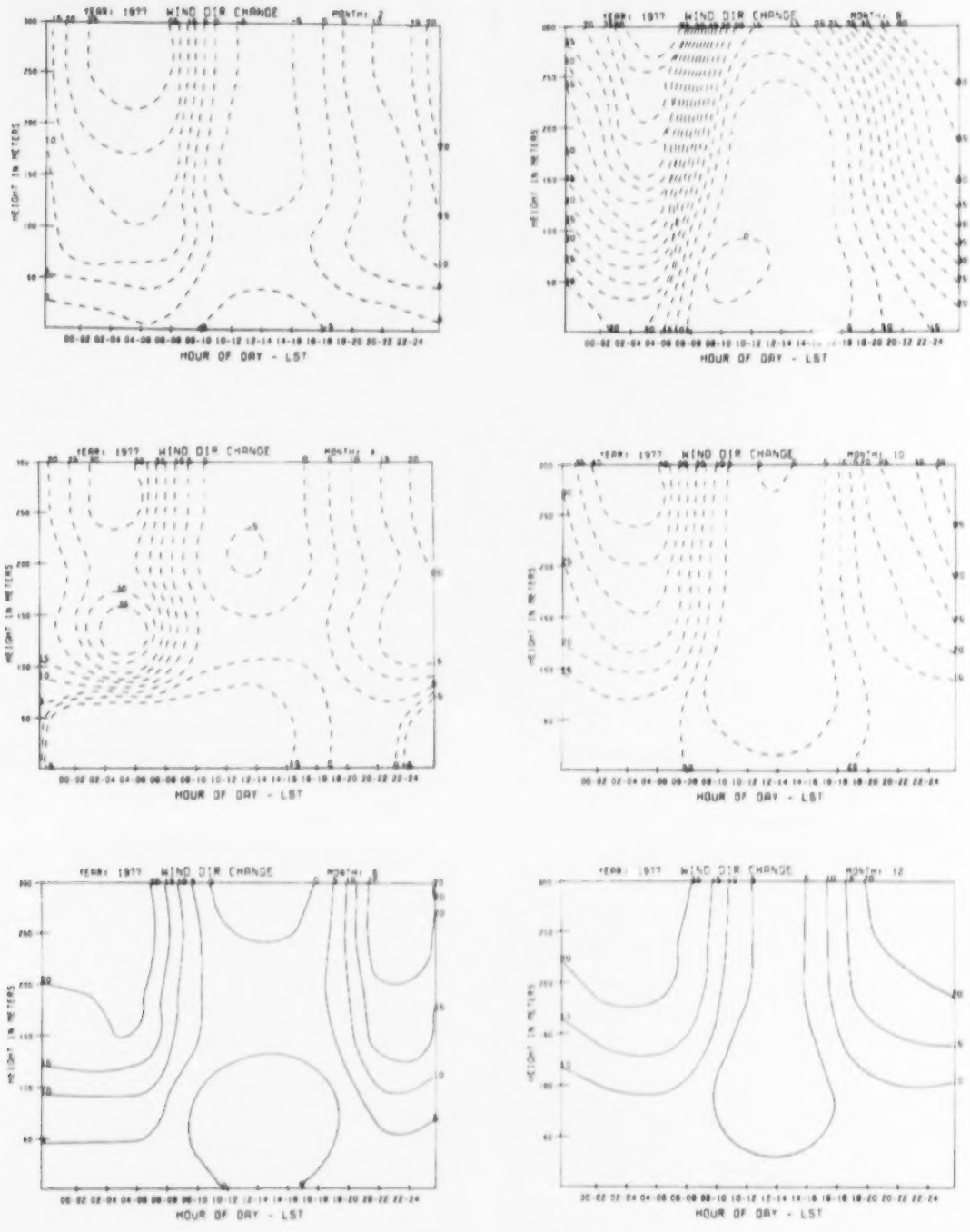

Figure 4-25. Observed monthly patterns of the diurnal course of the wind direction change with height for 1977.

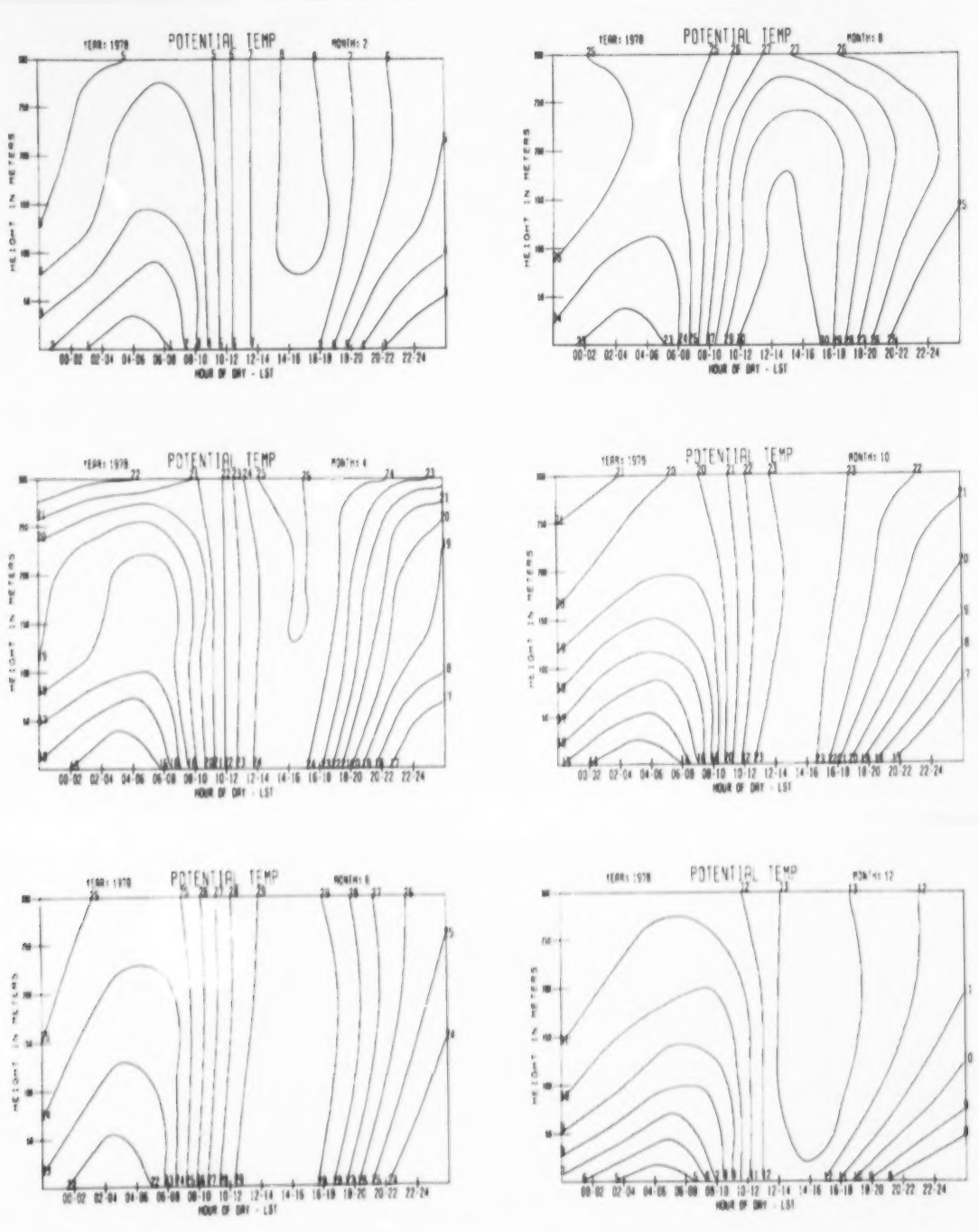

Figure 4-26. Observed monthly patterns of the diurnal course of the potential temperature for 1978.

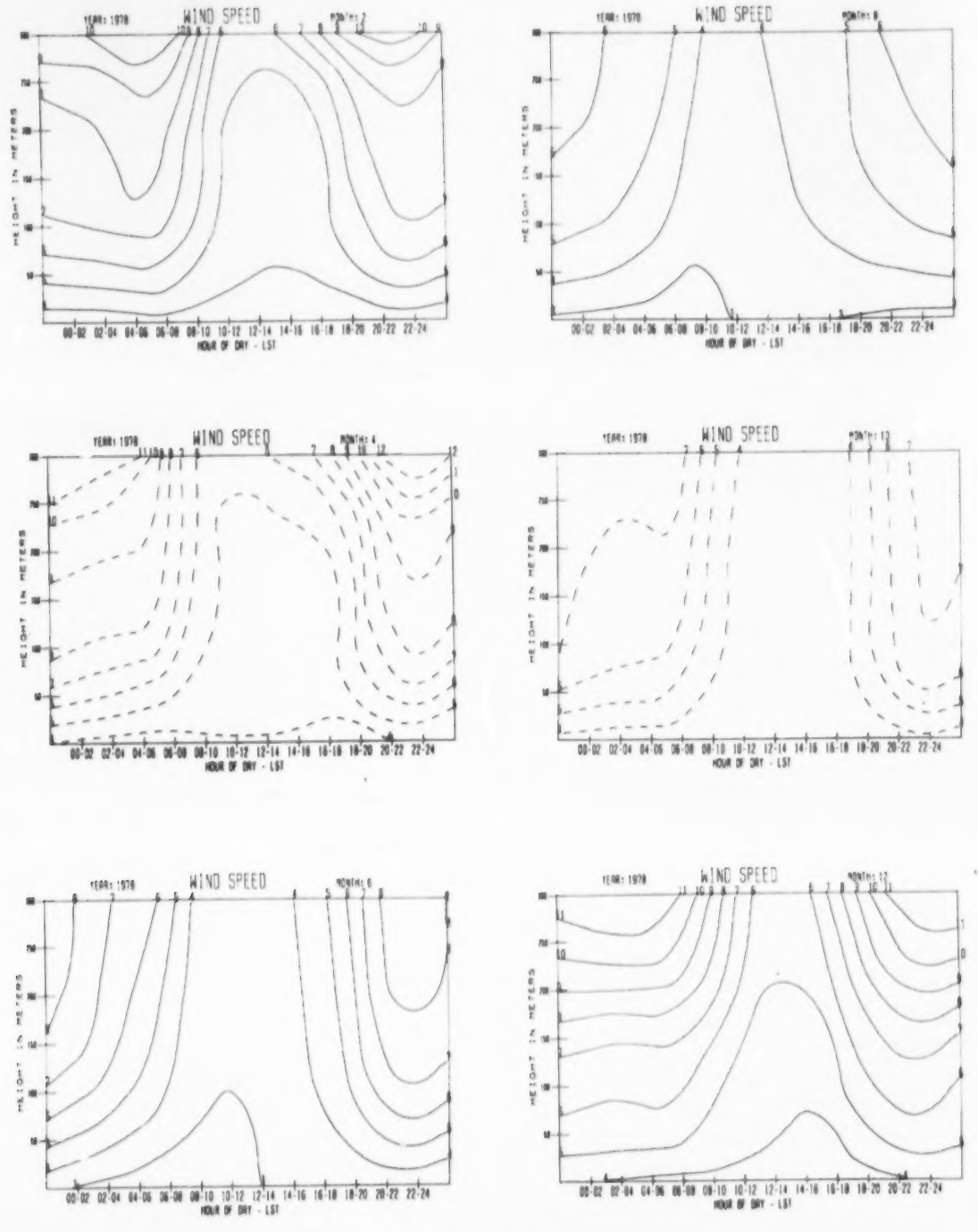

Figure 4-27. Observed monthly patterns of the diurnal course of the wind speed for 1978.

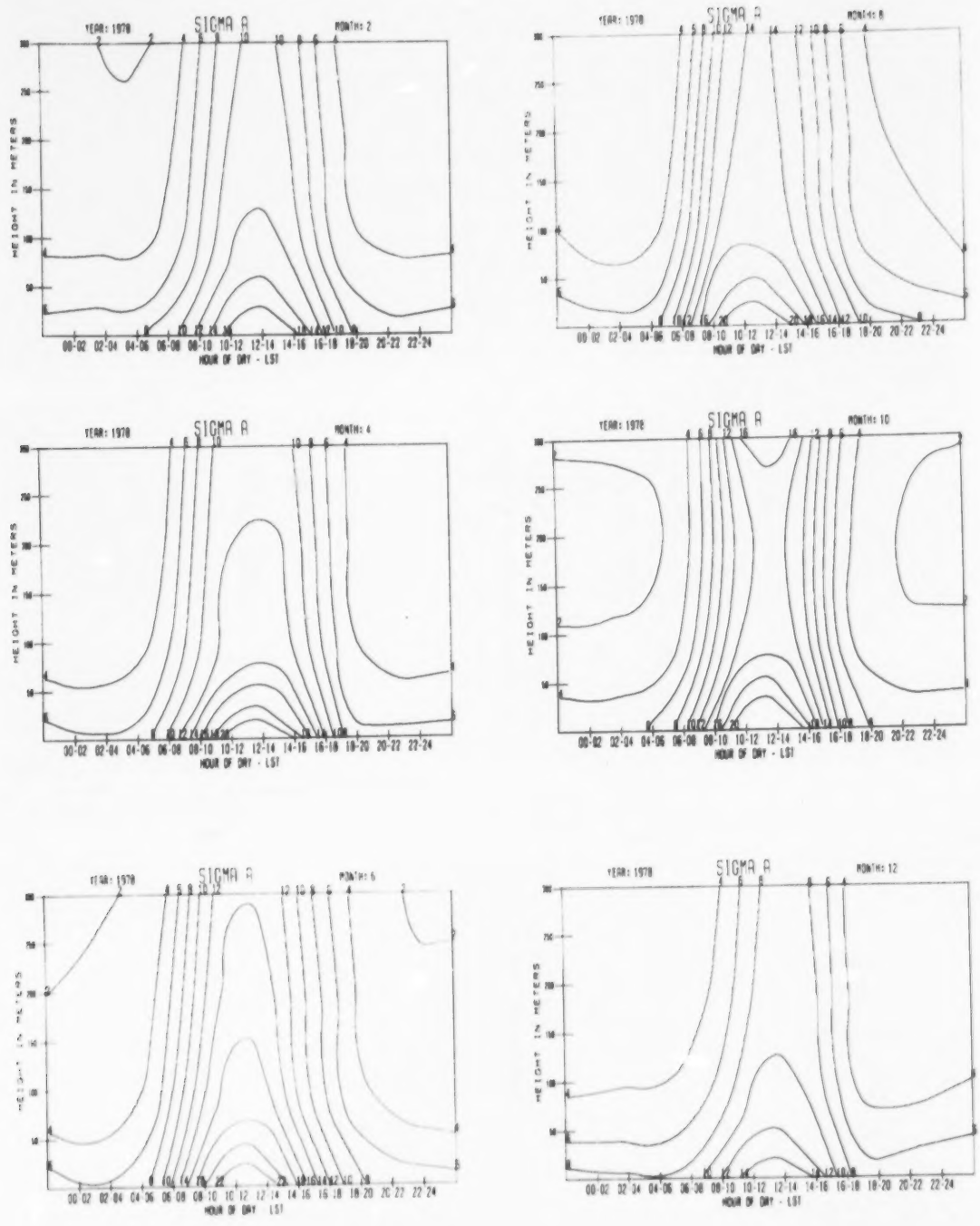

Figure 4-28. Observed monthly patterns of the diurnal course of the standard deviation of the horizontal wind direction for 1978.

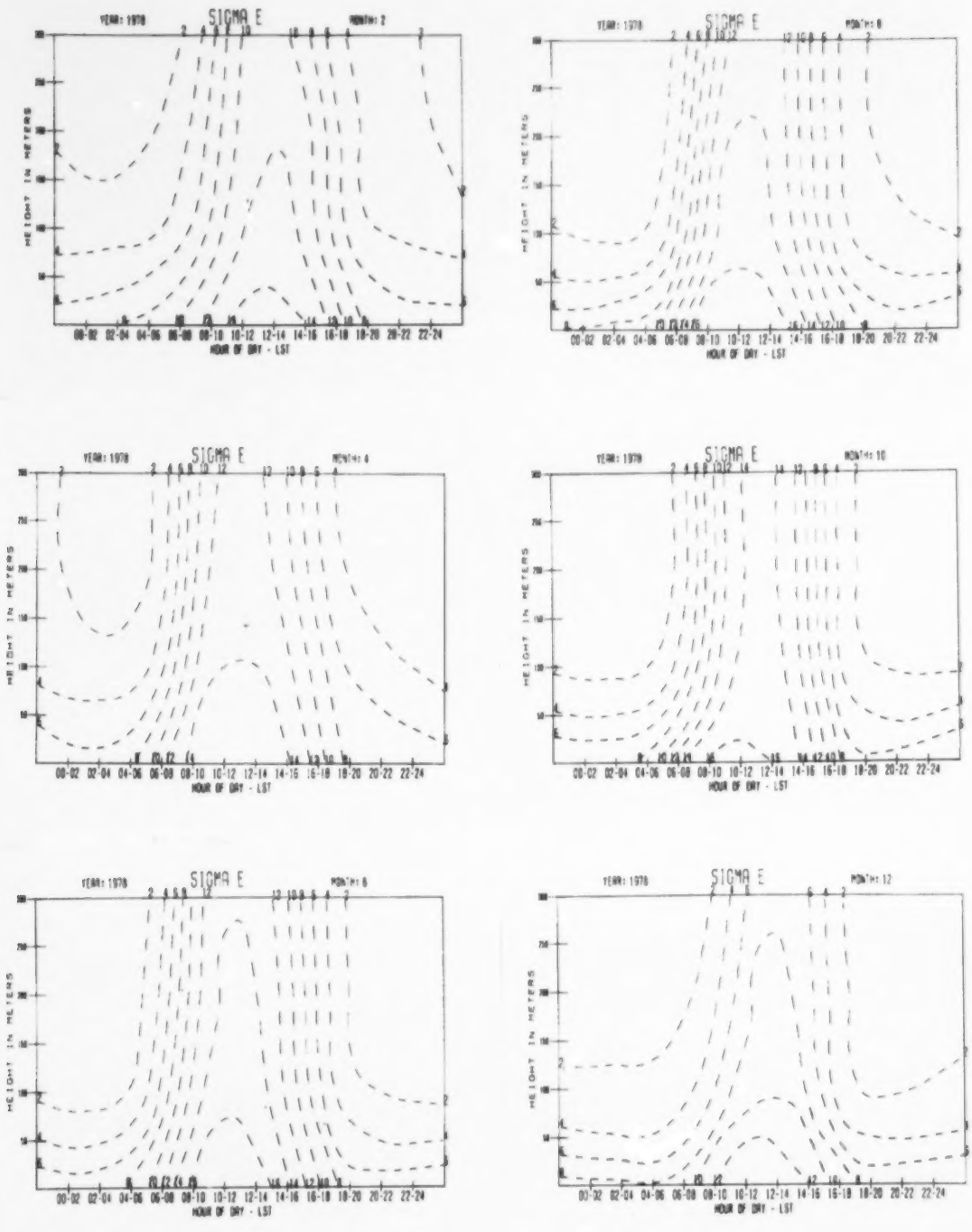

Figure 4-29. Observed monthly patterns of the diurnal course of the standard deviation of the vertical wind direction for 1978.

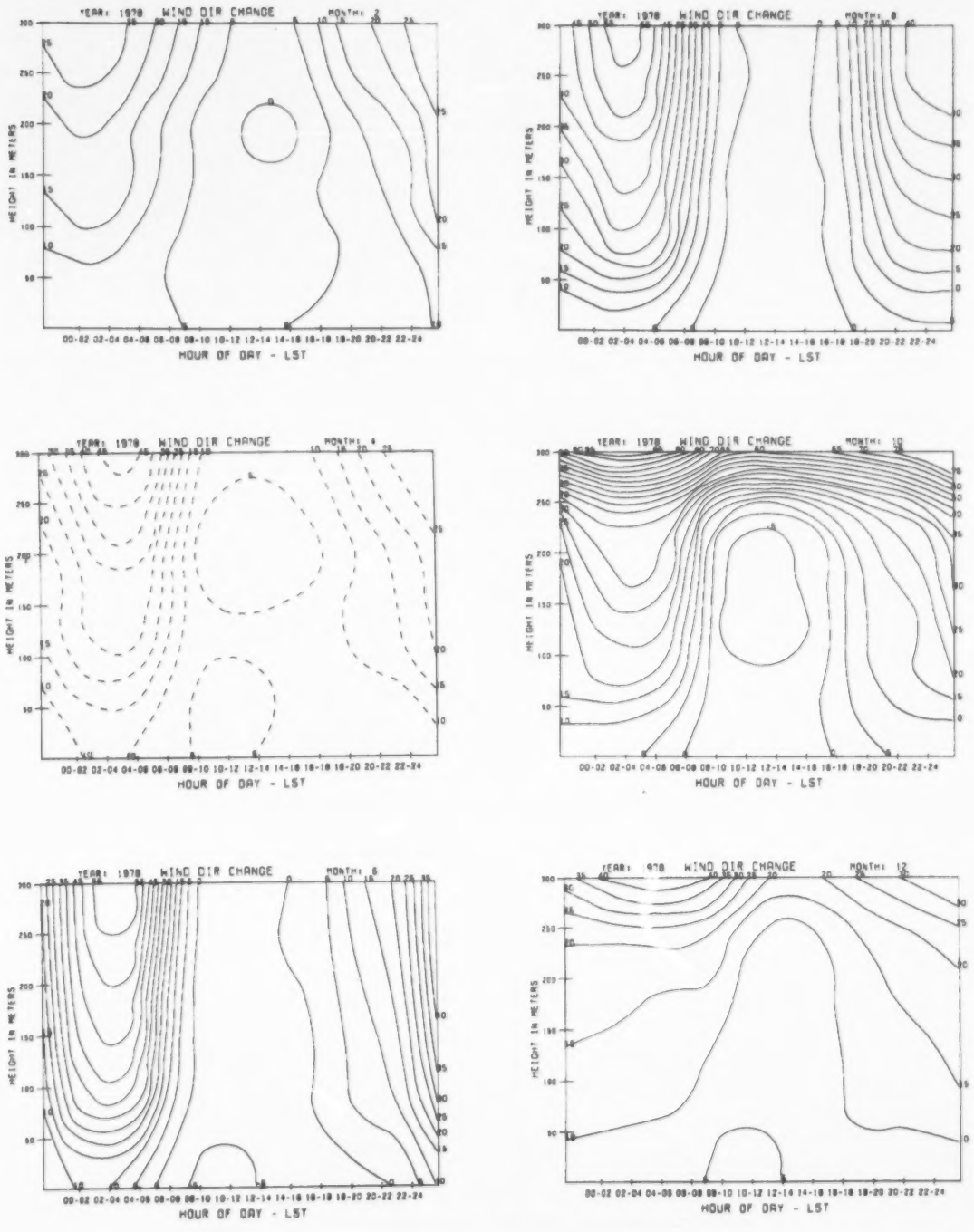
YEAR: 1978 WIND DIR CHANGE MONTH: 2
YEAR: 1978 WIND DIR CHANGE MONTH: 8
YEAR: 1978 WIND DIR CHANGE MONTH: 4
YEAR: 1978 WIND DIR CHANGE MONTH: 10
YEAR: 1978 WIND DIR CHANGE MONTH: 6
YEAR: 1978 WIND DIR CHANGE MONTH: 12
HEIGHT IN METERS
HOUR OF DAY - LST

Figure 4-30. Observed monthly patterns of the diurnal course of the wind direction change with height for 1978.

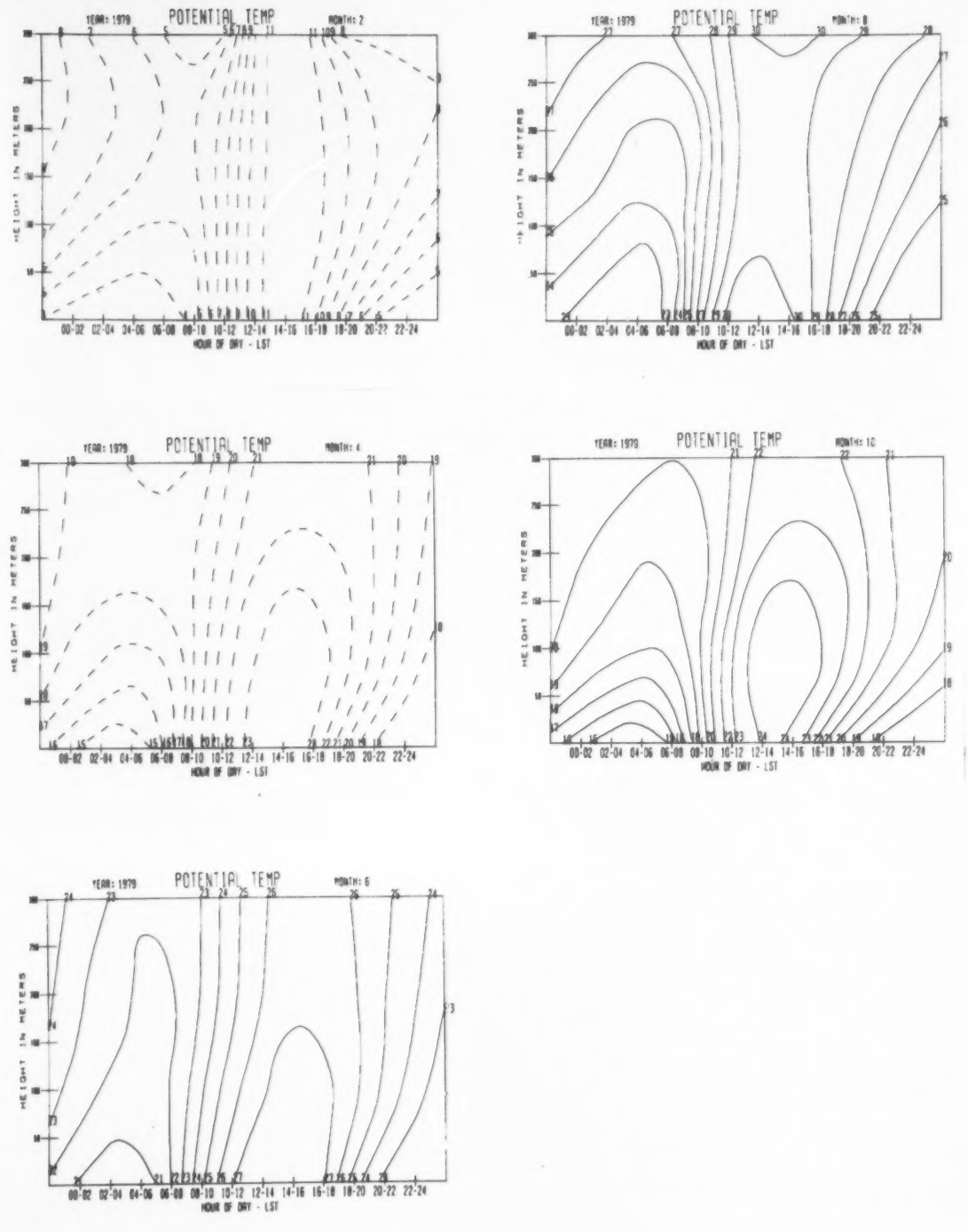

Figure 4-31. Observed monthly patterns of the diurnal course of the potential temperature for 1979.

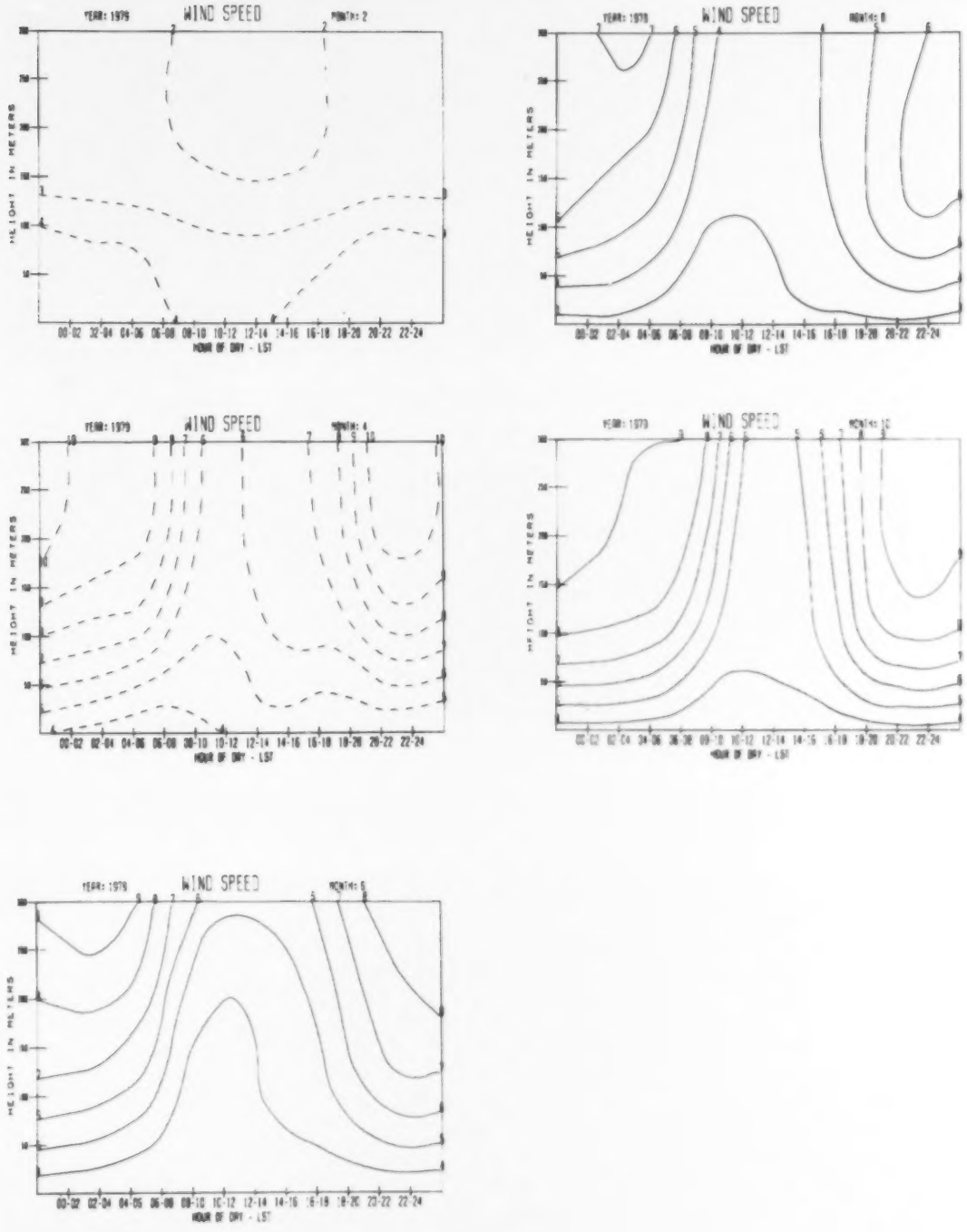

Figure 4-32. Observed monthly patterns of the diurnal course of the wind speed for 1979.

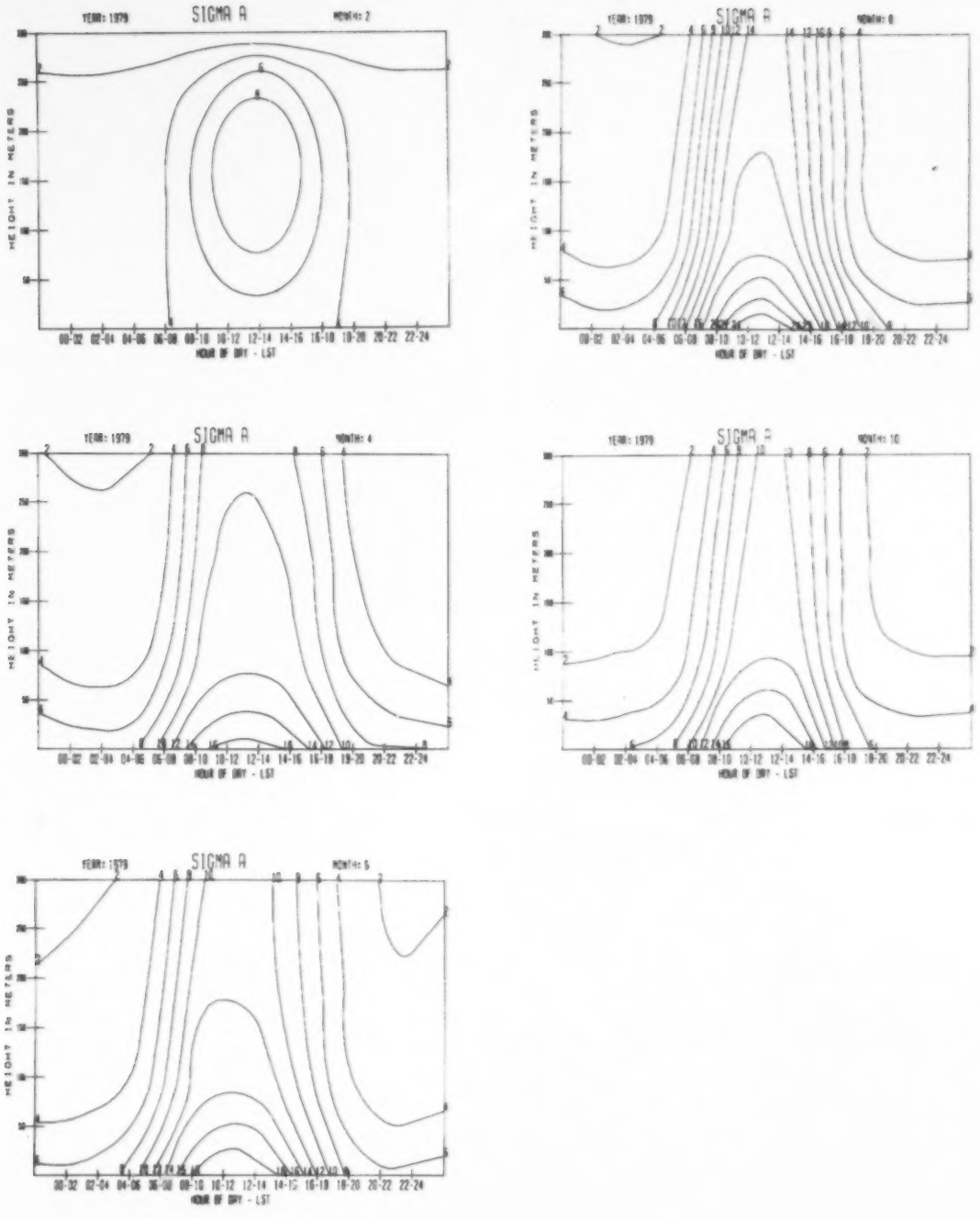

Figure 4-33. Observed monthly patterns of the diurnal course of the standard deviation of the horizontal wind direction for 1979.

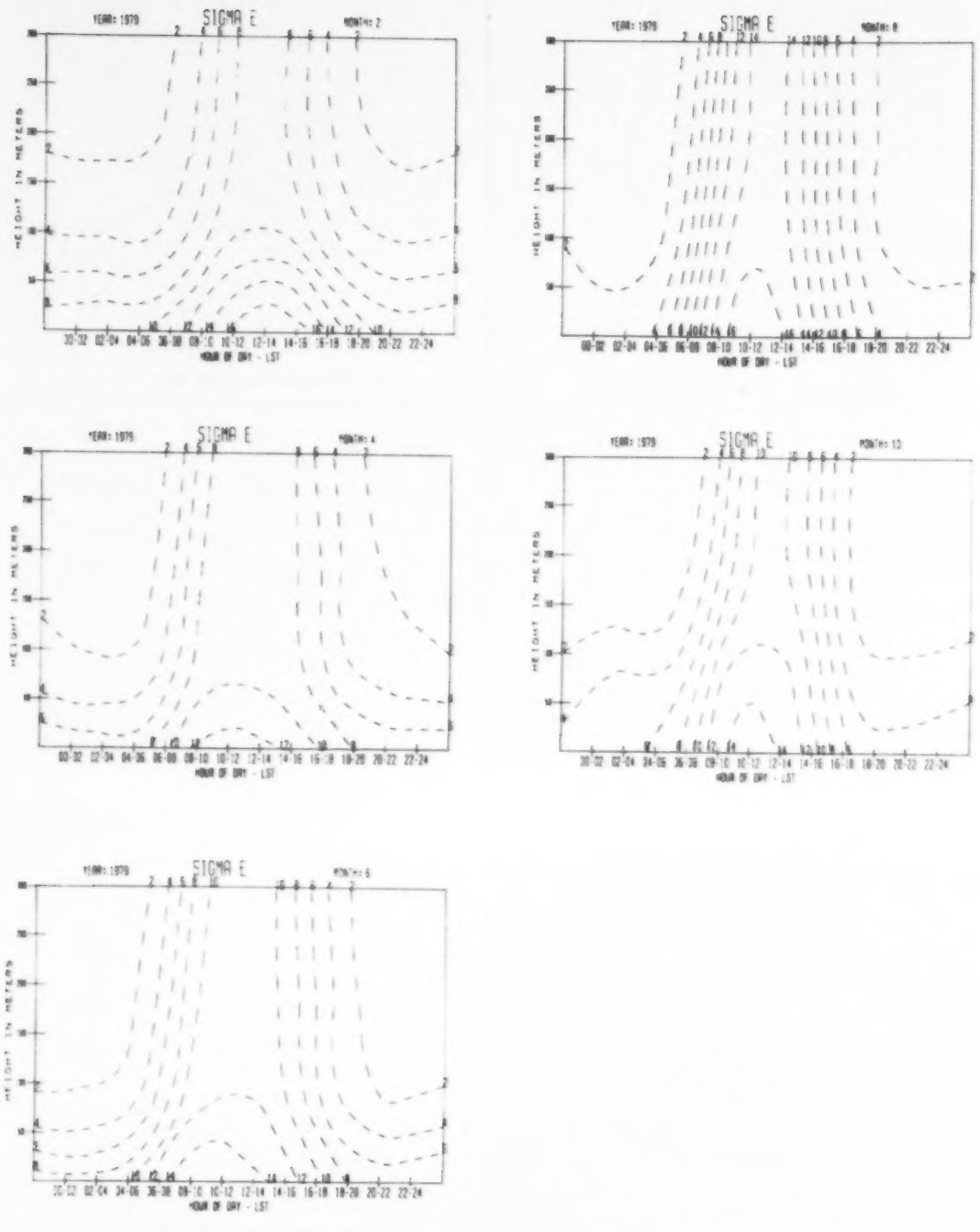

Figure 4-34. Observed monthly patterns of the diurnal course of the standard deviation of the vertical wind direction for 1979.

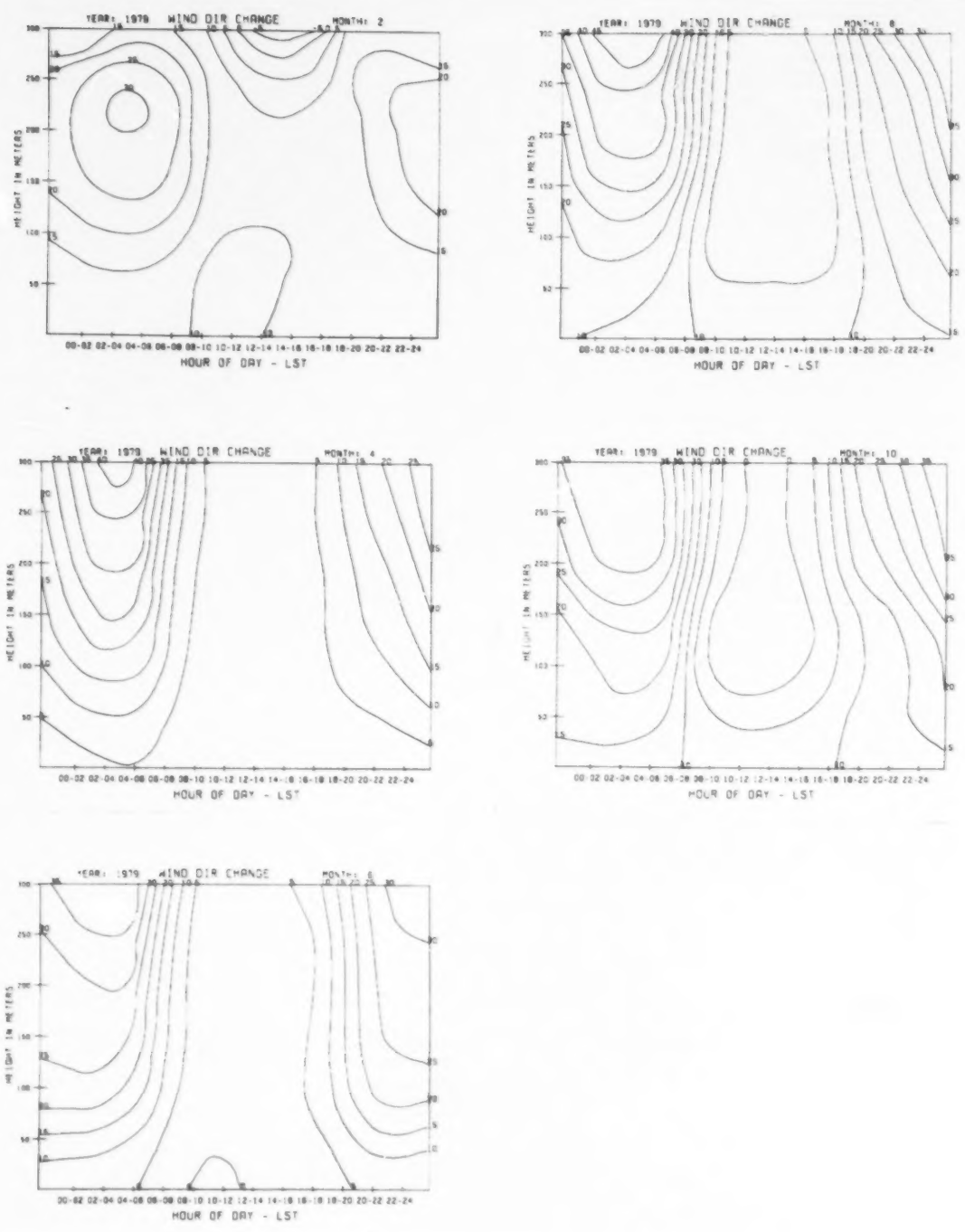
YEAR: 1979 WIND DIR CHANGE MONTH: 2
YEAR: 1979 WIND DIR CHANGE MONTH: 8
YEAR: 1979 WIND DIR CHANGE MONTH: 4
YEAR: 1979 WIND DIR CHANGE MONTH: 10
YEAR: 1979 WIND DIR CHANGE MONTH: 6
HEIGHT IN METERS
HOUR OF DAY - LST

Figure 4-35. Observed monthly patterns of the diurnal course of the wind direction change with height for 1979.

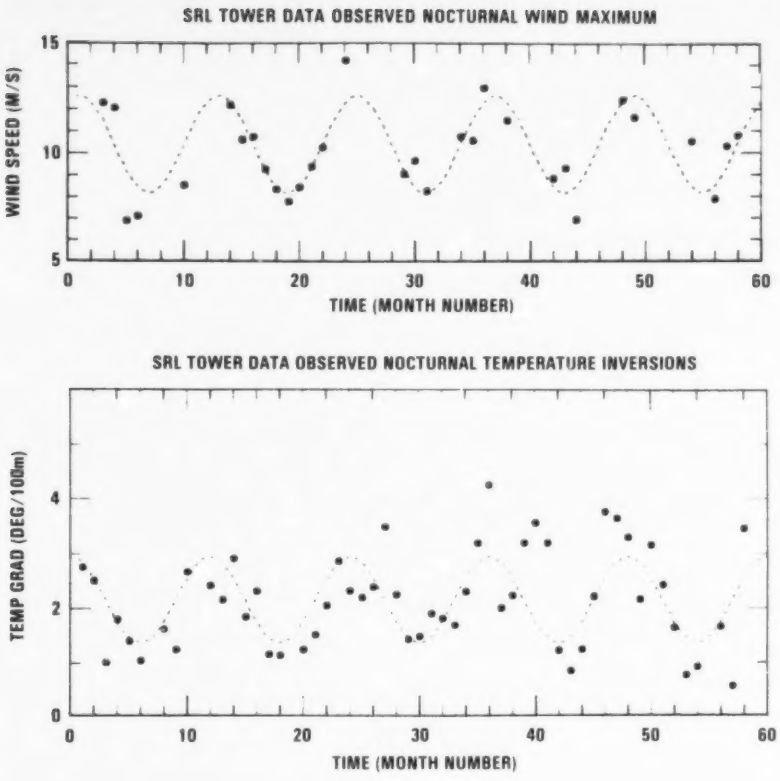

Figure 4-36. Median monthly values of the nocturnal wind speed maximum (m/s) and temperature inversion (C/100m) determined for the period 1975 through 1979. (Month 1 = January 1975; month 60 = December 1979).

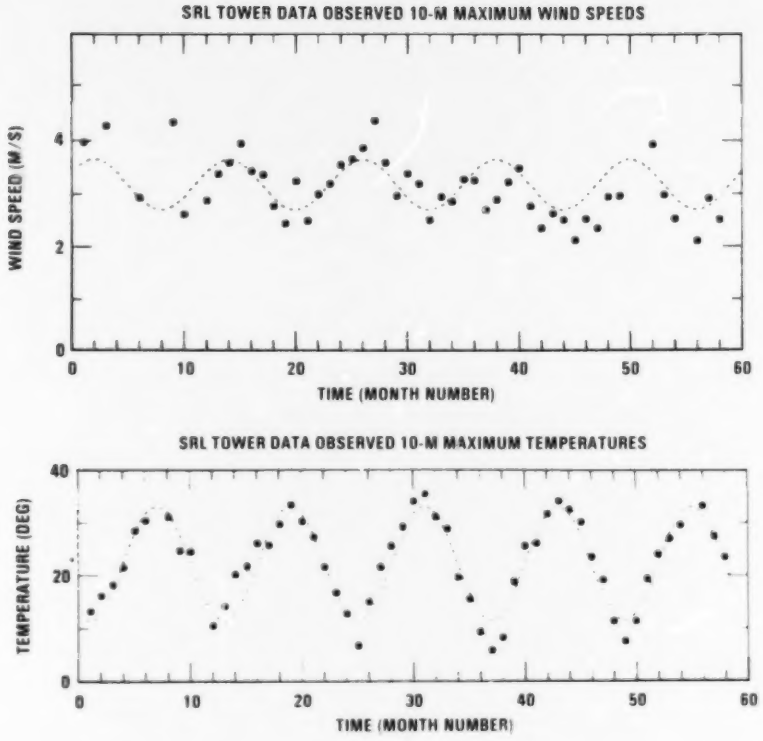

Figure 4-37. Median monthly values of 10-m maximum wind speeds (m/s) and temperature (C) determined for the period 1975 through 1979. (Month 1 = January 1975; month 60 = December 1979).

Table 4-1. Average Surface Roughness Length (cm) Determined from Alongwind Speed Turbulence Measurements for 1976. Only Cases With 10-m Wind Speeds Greater than 5 m/s were Considered and Results are Presented for Those Sectors Reporting at Least 30 Cases for Analysis For the Month. Within the Table the 10-m Results are Listed Above the 36-m Results.

30° Wind Sector	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
0- 30									22			
									28			
30- 60						30		33				
						73		33				
60- 90												
90-120												
120-150					22							
					28							
150-180			13									
			17									
180-210		23	15									
		37	39									
210-240		23	22									
		34										
240-270	26	29	26	28	15							
	20	19	34	36	53							
270-300	26	26	22	20	15					34	35	46
	20	23	27	33	37					34	35	28
300-330					3						34	49
					15						34	
330-360												

Table 4-2. Median Values of Surface Friction Velocity (m/s) Estimated for 1976 for Each Month and for Each Hour. Hours with Less Than 50 Cases to Choose From Have Been Left Blank.

Hour (LST)	Month 1	2	3	4	5	6	7	8	9	10	11	12
1	0.33	0.25	0.24	0.17	0.25	0.18					0.24	
2	0.30	0.30	0.26	0.18	0.19					0.18	0.20	
3	0.31	0.21	0.29	0.24	0.21					0.12	0.17	0.32
4	0.27	0.24	0.32	0.25	0.18					0.15	0.19	0.28
5	0.25	0.22	0.27	0.23	0.21	0.23				0.18	0.19	0.25
6	0.31	0.27	0.23	0.23	0.23	0.22			0.19	0.16	0.18	
7	0.26	0.26	0.24	0.29	0.27	0.26		0.24	0.23	0.23	0.22	0.21
8	0.25	0.27	0.25	0.35	0.35	0.29		0.28	0.26	0.30	0.30	
9	0.30	0.36	0.25	0.41	0.40	0.31		0.34	0.31	0.35	0.30	0.33
10	0.37	0.41	0.26	0.40	0.39	0.33		0.36	0.37	0.41	0.35	0.39
11	0.38	0.44	0.22	0.38	0.39	0.34	0.32	0.34	0.36	0.40	0.38	0.44
12	0.37	0.45	0.18	0.42	0.40	0.34	0.33	0.35	0.33	0.39	0.39	0.42
13	0.41	0.42	0.24	0.45	0.42	0.34	0.35	0.40	0.33	0.40	0.40	0.42
14	0.41	0.46	0.30	0.44	0.40	0.36	0.33	0.43	0.35	0.38	0.39	0.44
15	0.46	0.45	0.40	0.43	0.43	0.38	0.34	0.44	0.31	0.39	0.34	0.40
16	0.38	0.44	0.42	0.41	0.40	0.36	0.32	0.44	0.27	0.32	0.30	0.39
17	0.36	0.36	0.46	0.34	0.37	0.33	0.28	0.40	0.22	0.26	0.22	0.28
18	0.32	0.24	0.42	0.25	0.32	0.30		0.34			0.19	
19	0.28	0.23	0.45	0.20	0.27	0.29				0.17	0.20	0.21
20	0.34	0.33	0.46	0.26	0.32	0.23				0.19	0.16	
21	0.32	0.30	0.48	0.30	0.32						0.17	0.26
22	0.34	0.33	0.44	0.27	0.31	0.20					0.18	0.26
23	0.33	0.29	0.37	0.23	0.31	0.18					0.16	0.24
24		0.25	0.29	0.19	0.27	0.13				0.16	0.24	0.28

Table 4-3. Median Values of Surface Heat Flux (W/m^2) Estimated For 1976 for Each Month and for Each Hour. Hours With Less Than 50 Cases to Choose From Have Been Left Blank.

Hour	Month											
(LST)	1	2	3	4	5	6	7	8	9	10	11	12
1	-25	-23	-18	-17	-16	-12					-17	
2	-28	-23	-16	-16	-14					-14	-13	
3	-32	-20	-16	-24	-14					-11	-12	-27
4	-23	-22	-18	-27	-12					-12	-15	-17
5	-21	-21	-17	-25	-14	-14				-13	-15	-18
6	-24	-26	-11	-17	-9	-8			-12	-14	-15	
7	-25	-21	-11	-25	27	-3		-1	-6	-8	-16	-15
8	-13	-2	-3	98	23	56		7	-3	49	-2	
9	23	65	21	152	36	122		30	24	113	72	-5
10	85	121	35	192	94	140		91	34	148	115	4
11	120	153	80	218	104	187	180	172	125	176	138	75
12	128	167	41	228	112	156	220	197	98	178	139	54
13	122	162	41	216	106	151	211	182	78	158	125	14
14	91	141	83	186	104	145	188	162	148	127	96	56
15	56	96	75	144	82	136	162	136	97	84	45	-5
16	-2	44	33	89	60	93	111	92	40	27	-9	-15
17	-20	-15	-10	40	-1	45	68	42	-6	-14	-16	-21
18	-23	-20	-19	-14	-10	-10		-17			-12	
19	-24	-19	-18	-20	-18	-17				-14	-14	-19
20	-27	-27	-20	-20	-20	-12				-14	-14	
21	-22	-26	-22	-27	-21						-13	-23
22	-22	-32	-24	-24	-19	-12					-13	-17
23	-24	-27	-22	-22	-20	-11					-12	-18
24		-24	-19	-19	-16	-11				-12	-15	-18

Table 4-4. Median Values of Monin-Obukhov Length (m) Estimated for 1976 for Each Month and for Each Hour. Hours with Less Than 50 Cases to Choose From Have Been Left Blank.

Hour (LST)	Month 1	2	3	4	5	6	7	8	9	10	11	12
1	119	71	89	32	102	42					69	
2	89	79	82	39	58					34	52	
3	101	48	74	48	59					26	39	109
4	69	67	88	63	50					28	32	86
5	65	50	76	48	64	62				33	37	91
6	90	67	53	68	112	109			55	29	35	
7	86	82	128	-272	-2109	950		1130	179	132	84	68
8	145	583	707	-78	-106	-57		-433	381	-60	784	
9	-316	-84	-258	-53	-52	-27		-87	-91	-41	-100	870
10	-100	-72	-97	-44	-52	-30		-39	-39	-39	-78	-697
11	-52	-69	-91	-41	-70	-24	-23	-20	-33	-36	-77	-102
12	-52	-59	-98	-50	-80	-30	-20	-22	-25	-39	-71	-111
13	-170	-45	-78	-55	-70	-25	-23	-30	-27	-46	-92	-171
14	-313	-96	-109	-53	-55	-32	-20	-40	-28	-46	-144	-277
15	-193	-156	-125	-61	-69	-43	-25	-56	-67	-68	-256	835
16	1282	-256	-921	-77	-201	-58	-33	-94	-141	-215	220	288
17	165	264	586	-113	-13905	-107	-35	-150	146	109	63	105
18	119	66	116	109	294	376		185			49	
19	85	47	70	53	112	142				37	44	70
20	122	115	91	75	143	86				52	34	
21	119	109	110	91	144						31	79
22	158	102	125	69	127	60					33	105
23	143	88	96	50	158	44					38	76
24		68	58	36	116	28				33	74	107

Table 4-5. Quartile Values of Monin-Obukhov Stability Length (L), Standard Deviation of Vertical Wind Direction Fluctuation (Se) and Standard Deviation of Lateral Wind Direction Fluctuation (Sa) Determined for Each Pasquill Stability Class From the SRL 10-m Data for 1976. In the Second Part of the Table are Shown the Monin-Obukhov Values Estimated by Golder (1972) Using a Roughness Length of 0.3 m and the Wind Fluctuation Standard Deviations Estimated Using the Golder L-Values and Binkowski (1979) Surface-Layer Similarity Relationships.

	L (meters)				Se (degrees)				Sa (degrees)			
Class	25%	50%	75%	N	25%	50%	75%	N	25%	50%	75%	N
A	-9	-13	-22	257	14.4	18.1	22.8	269	27.2	33.6	41.3	259
B	-13	-21	-38	2053	12.6	15.7	20.1	1929	19.8	25.8	33.5	2183
C	-29	-56	-110	3021	10.8	12.8	15.7	2446	16.3	20.4	26.1	3173
DD*	-104	-296	1236	4727	10.1	11.7	14.5	3719	14.0	16.4	20.3	4923
DN*	69	147	276	4000	8.6	10.3	12.5	3489	10.6	12.9	15.4	4649
E	32	69	126	2249	7.3	9.2	11.2	1822	9.2	11.2	13.7	2647
F	11	33	71	2120	4.3	6.7	9.6	2776	6.9	9.5	12.5	2739
G	8	12	36	1264	2.7	4.3	6.9	3247	5.4	7.6	10.7	4169

	Estimated L(m)	Estimated Se (degrees)	Estimated Sa (degrees)
A	-8	19.6	33.6
B	-14	15.9	27.0
C	-33	11.7	18.3
D	-100	9.4	13.6
E	100	7.4	9.8
F	33	6.0	7.5
G	14	4.3	5.1

* Results are shown separately for the daytime neutral cases (DD), and the nighttime neutral cases (DN). Daytime is defined as the period one hour after sunrise through one hour before sunset.

Table 4-6. Estimated Correction to be Applied to the 10-m Temperature Values. Estimates Formed Using 1976 Data.

Month	Correction (°C)
JAN	-1.1900
FEB	-1.0060
MAR	-0.0050
APR	-0.0050
MAY	+0.6550
JUN	+0.9925
JUL	+0.9900
AUG	-0.2750
SEP	-0.7775
OCT	-1.9875
NOV	-2.6100
DEC	-2.8300

Table 4-7. Summary of 15-min Wind Speed Values for Selected Heights and Times During the Day. For a Winter Season Month (February) and a Summer Season Month (June) Three Values are Listed for Each 2-hour Block: the 90-th Percentile, the 50-th Percentile (Median) and the 10-th Percentile.

Wind Speed (m/s)

February 1976

Height(m)		Hour of Day (LST) 01/03	07/09	13/15	19/21
	90	14.87	16.01	12.21	13.35
304	50	11.47	10.47	4.85	7.89
	10	6.66	6.71	2.58	2.72
	90	13.73	12.95	11.80	12.83
182	50	10.96	10.23	5.70	8.56
	10	7.32	7.00	3.21	3.62
	90	8.61	8.53	9.38	9.09
91	50	6.70	5.36	4.39	8.38
	10	3.83	3.20	2.58	5.79
	90	3.66	5.12	6.68	5.12
10	50	2.54	2.36	3.73	2.42
	10	1.40	1.23	2.12	1.35

June 1976

Height(m)		Hour of Day (LST) 01/03	07/09	13/15	19/21
	90	12.60	11.09	7.80	11.30
304	50	8.31	6.73	4.94	6.75
	10	4.75	3.74	2.41	2.30
	90	10.34	9.04	7.63	9.79
182	50	7.62	5.24	4.65	5.99
	10	4.60	3.20	2.41	2.75
	90	7.48	6.18	6.99	6.93
91	50	5.61	3.43	3.92	4.82
	10	4.30	1.77	2.07	2.67
	90	3.11	3.95	4.74	3.66
10	50	1.79	2.14	2.71	1.82
	10	1.22	1.30	1.52	1.21

Table 4-8. Summary of 15-min Standard Deviations of the Horizontal Wind Direction for Selected Heights and Times During the Day. For a Winter Season Month (February) and a Summer Season Month (June) Three Values are Listed for Each 2-hour Block: the 90-th Percentile, the 50-th Percentile (median) and the 10-th Percentile.

Standard Deviation of the Horizontal Wind Direction (degrees)

February 1976

Height(m)		Hour of Day (LST) 01/03	07/09	13/15	19/21
	90	4.11	3.74	21.23	5.10
304	50	1.68	1.37	11.23	2.11
	10	0.80	0.81	4.94	1.05
	90	5.49	5.04	22.36	6.17
182	50	2.15	1.98	13.06	2.36
	10	0.92	0.90	6.27	0.99
	90	6.23	6.31	27.83	7.03
91	50	3.03	3.16	14.43	3.19
	10	1.41	1.33	8.66	1.36
	90	15.86	18.15	43.24	21.10
10	50	8.88	9.78	21.88	8.84
	10	5.16	4.90	14.81	4.51

June 1976

Height(m)		Hour of Day (LST) 01/03	07/09	13/15	19/21
	90	5.32	7.19	22.42	7.20
304	50	1.94	3.21	11.75	3.34
	10	0.96	1.14	5.49	1.47
	90	7.12	13.74	23.70	8.00
182	50	2.63	6.03	12.95	3.84
	10	1.07	1.82	6.07	1.57
	90	8.79	16.31	29.51	11.62
91	50	3.74	8.99	15.29	5.28
	10	1.66	3.92	8.49	2.16
	90	16.51	24.48	42.01	17.03
10	50	11.01	15.97	22.96	11.90
	10	6.44	12.48	15.39	5.75

Table 4-9. Summary of 15-min Standard Deviations of the Vertical Wind Direction for Selected Heights and Times During the Day. For Winter Season Month (February) and a Summer Season Month (June) Three Values are Listed for Each 2-hour Block: the 90-th Percentile, the 50-the Percentile (median) and the 10-th Percentile.

Standard Deviation of the Vertical Wind Direction (degrees)

February 1976

Height(m)		Hour of Day (LST) 01/03	07/09	13/15	19/21
	90	3.49	7.06	16.70	5.37
304	50	0.67	0.51	10.44	1.41
	10	0.29	0.31	4.31	0.42
	90	3.66	3.84	17.65	3.88
182	50	0.96	0.79	10.63	1.12
	10	0.31	0.29	4.97	0.37
	90	4.64	4.90	19.61	4.78
91	50	1.99	1.52	11.41	1.71
	10	0.50	0.52	6.64	0.44
	90	26.24	21.25	28.65	22.38
10	50	7.59	8.66	16.05	7.93
	10	3.24	3.08	8.52	2.10

June 1976

Height(m)		Hour of Day (LST) 01/03	07/09	13/15	19/21
	90	2.87	9.22	18.37	3.69
304	50	0.87	2.36	8.89	1.47
	10	0.41	0.57	4.32	0.61
	90	5.32	7.66	16.56	4.28
182	50	1.08	3.80	9.43	1.74
	10	0.34	0.74	5.22	0.71
	90	6.46	15.03	21.31	6.55
91	50	2.10	7.62	11.28	3.08
	10	0.76	2.55	6.23	0.93
	90	13.26	22.75	20.55	12.66
10	50	6.94	13.04	13.07	8.06
	10	2.87	9.95	9.94	2.92

Table 4-10. Summary of 15-min Wind Direction Change for Selected Heights and Times During the Day. For a Winter Season Month (February) and a Summer Season Month (June) Three Values are listed for Each 2-hour block: the 90-th Percentile, the 50-th Percentile (median) and the 10-th Percentile.

Wind Direction Change (degrees)

February 1976

Height(m)		Hour of Day (LST) 01/03	07/09	13/15	19/21
	90	61.82	81.24	19.12	55.56
304	50	26.09	40.02	3.28	15.02
	10	3.57	6.25	-11.08	0.45
	90	50.84	79.64	12.49	38.81
182	50	16.98	34.03	0.75	10.61
	10	0.59	3.76	-9.76	-0.31
	90	35.37	72.46	15.60	36.61
91	50	13.07	21.32	4.39	8.47
	10	-0.07	0.60	-4.74	-0.05
	90	21.01	41.77	12.28	24.38
36	50	9.13	10.14	5.38	7.93
	10	0.86	1.07	-1.98	-4.68

June 1976

Height(m)		Hour of Day (LST) 01/03	07/09	13/15	19/21
	90	61.53	47.49	14.75	30.74
304	50	27.40	14.93	-6.87	2.71
	10	-6.77	-12.57	-22.56	-18.69
	90	55.82	30.79	10.29	23.59
182	50	22.32	5.80	-6.47	1.26
	10	-9.50	-8.91	-19.87	-14.90
	90	42.89	18.78	9.62	19.97
91	50	10.30	0.82	-3.65	-0.15
	10	-5.48	-7.68	13.35	-11.52
	90	30.04	15.11	15.16	17.72
36	50	10.08	5.48	3.65	7.16
	10	1.99	-1.96	-5.44	-3.49

Table 4-11. Characteristic (Key) Features of Diurnal Patterns for Each Meteorological Variable.

Potential Temperature
10-meter
average value
maximum value and hour of occurrence
minimum value and hour of occurrence
Nocturnal structure
inversion strength when a 10-m minimum temperature occurs
Wind Speed
10-meter
average value
maximum value and hour of occurrence
minimum value and hour of occurrence
Nocturnal structure
maximum value, height and time of occurrence
gradient in the vertical between maximum and 10-m value
Wind Direction Fluctuations
10-meter
average value
maximum value and hour of occurrence
minimum value and hour of occurrence
Horizontal Wind Direction Shear
maximum value, height and time of occurrence

Table 4-12. Potential Temperature Key Feature Values for the 10-m Level Data.

	Average (c)	Maximum (c)	Time of Maximum (hr)	Minimum (c)	Time of Minimum (hr)
1975					
1	8.98	13.16	16	6.17	8
2	10.20	16.19	16	5.71	6
3	12.74	18.26	16	8.17	6
4	16.80	21.53	16	12.89	6
5	23.24	28.54	14	19.44	4
6	25.61	30.46	16	21.44	4
7					
8	24.93	31.06	16	20.99	6
9	20.88	24.67	14	18.90	6
10	18.35	24.44	14	13.86	6
11					
12	5.31	10.45	14	2.15	6
1976					
1	7.56	14.02	16	2.40	8
2	13.38	20.18	16	7.75	6
3	16.80	21.73	16	12.84	6
4	18.50	26.00	16	11.50	6
5	21.17	25.78	16	17.60	6
6	24.78	29.77	14	21.14	6
7		33.42	14		
8	25.19	30.24	14	21.47	6
9	22.38	27.32	14	19.47	4
10	16.21	21.60	16	12.17	6
11	10.75	16.78	14	6.28	6
12	7.54	12.64	14	3.63	8
1977					
1	1.96	6.61	16	-1.07	2
2	7.23	15.00	16	0.75	6
3	14.85	21.52	14	8.00	6
4	19.04	25.65	14	12.90	6
5	23.05	29.20	16	18.00	6
6	27.35	34.07	14	21.56	4
7	28.56	35.49	14	22.50	4
8	25.22	31.19	16	20.49	6
9	23.53	28.83	14	20.37	4
10	14.79	19.62	14	11.74	2
11	10.72	15.43	16	7.20	4
12	4.80	9.29	16	-0.12	8

Table 4-12. (Continued). Potential Temperature Key Feature Values for the 10-m Level Data.

	Average (c)	Maximum (c)	Time of Maximum (hr)	Minimum (c)	Time of Minimum (hr)
1978					
1	0.96	5.72	16	-1.27	4
2	2.35	8.14	16	-1.39	4
3	11.55	18.72	16	6.14	4
4	18.23	25.55	16	11.96	6
5	21.29	26.11	14	16.22	4
6	25.91	31.68	14	21.25	4
7	27.59	34.13	16	22.90	6
8	25.72	32.44	14	20.92	6
9	23.26	30.11	14	18.33	6
10	15.23	23.52	14	9.05	6
11	12.59	19.08	14	8.15	6
12	4.94	11.29	14	1.31	8
1979					
1	3.04	7.51	14	0.30	8
2	4.73	11.35	16	1.55	24
3	13.87	19.34	16	9.21	6
4	18.02	24.08	16	13.05	6
5	21.64	27.00	14	17.80	6
6	24.06	29.56	16	19.93	6
7					
8	26.37	33.17	14	21.86	6
9	23.06	27.54	14	20.53	6
10	16.42	23.49	14	10.23	5

Table 4-13. Potential Temperature at the 304-m Level When the 10-m Temperature is at a Minimum

Month	YEAR 1975	1976	1977	1978	1979
1	14.28	8.76	5.42	4.63	6.66
2	13.10	16.35	7.81	5.18	
3	11.10	18.29		15.51	
4	18.17	18.31	19.51	22.42	17.87
5	23.55	21.01	22.19		20.02
6	24.45	24.47	25.90	24.85	22.58
7			28.09	25.37	
8	27.16	25.09	25.83	24.54	26.76
9	22.54	23.96	25.32	24.85	
10	21.72	18.32	18.52	20.12	20.37
11		14.72	16.59	18.90	NA
12	9.28	10.45	12.39	11.00	NA

Table 4-14. Maximum Nocturnal Potential Temperature Inversion Stength (C/100m).

Month	1975	1976	1977	1978	1979
1	2.75	2.15	2.20	2.00	2.16
2	2.50	2.91	2.39	2.23	3.14
3	0.99	1.85	3.48	3.18	2.42
4	1.79	2.31	2.24	3.54	1.63
5	1.39	1.15	1.42	3.18	0.75
6	1.03	1.13	1.47	1.22	0.90
7			1.89	0.84	
8	1.61	1.23	1.81	1.23	1.66
9	1.23	1.52	1.68	2.21	0.54
10	2.66	2.05	2.30	3.75	3.44
11		2.86	3.18	3.64	NA
12	2.42	2.31	4.24	3.28	NA

Table 4-15. Wind Speed Key Features for the 10-m Level Data.

	Average (m/s)	Maximum (m/s)	Time of Maximum (hr)	Minimum (m/s)	Time of Minimum (hr)
1975					
1	2.83	3.97	14	2.19	4
2					
3	3.34	4.27	16	2.46	6
4					
5					
6	2.23	2.92	14	1.83	2
7					
8					
9	3.00	4.35	14	2.15	2
10	2.13	2.61	12	1.64	18
11					
12	2.34	2.87	14	1.94	20
1976					
1	2.89	3.38	16	2.53	8
2	2.72	3.59	16	2.31	4
3	2.86	3.95	16	2.06	6
4	2.63	3.42	14	2.02	20
5	2.58	3.35	16	1.94	4
6	2.11	2.77	16	1.79	2
7		2.43	14		
8	2.19	3.23	16	1.56	2
9	2.01	2.49	10	1.56	20
10	2.33	2.99	14	1.96	20
11	2.38	3.19	14	2.02	18
12	2.80	3.55	14	2.22	18
1977					
1		3.66	16	2.52	8
2	2.73	3.86	16	2.08	2
3	3.38	4.39	16	2.60	20
4	2.57	3.59	16	1.74	6
5	2.23	2.95	16	1.70	6
6	2.52	3.37	14	1.84	20
7	2.56	3.19	14	1.58	2
8	1.94	2.50	16	1.49	6
9		2.94	10	1.71	24
10	2.26	2.85	12	1.92	18
11	2.27	3.27	14	1.80	6
12	2.33	3.26	14	1.86	4

Table 4-15. (Continued). Wind Speed Key Features for the 10-m Level Data.

	Average (m/s)	Maximum (m/s)	Time of Maximum (hr)	Minimum (m/s)	Time of Minimum (hr)
1978					
1		2.70	16	1.77	20
2	2.13	2.89	14	1.74	6
3	2.44	3.21	16	1.80	6
4	2.60	3.48	12	2.05	2
5	2.21	2.76	16	1.71	2
6	1.84	2.34	14	1.37	4
7	2.02	2.62	16	1.53	6
8	1.69	2.51	14	1.31	24
9	1.67	2.13	14	1.37	20
10	1.89	2.52	12	1.49	18
11	1.88	2.34	12	1.53	18
12	2.33	2.94	12	1.90	20
1979					
1	2.68	2.96	10	2.32	20
1					
3					
4	2.61	3.93	16	1.89	6
5	2.15	2.98	12	1.64	2
6	2.00	2.53	14	1.61	24
7					
8	1.65	2.11	14	1.33	6
9	2.25	2.91	10	1.80	20
10	1.93	2.50	14	1.58	18

Table 4-16. Wind Speed Maximum Key Feature Values.

	Maximum Value (m/s)	Height of Maximum (m)	Time of Maximum (hr)	Wind Speed Shear (sec^{-1})
1975				
1				
2				
3	12.27	305	24	31
4	12.04	305	2	
5	6.87	305	24	
6	7.07	305	6	17
7				
8				
9				
10	8.52	182	2	38
11				
12				
1976				
1				
2	12.18	243	2	41
3	10.59	243	24	35
4	10.72	243	22	34
5	9.26	305	24	23
6	8.34	305	24	22
7	7.79	305	2	
8	8.45	305	22	22
9	9.41	305	2	26
10	10.25	305	24	28
11				
12	14.23	305	4	39
1977				
1				
2				
3				
4				
5	9.03	305	2	25
6	9.64	305	6	26
7	8.26	182	24	37
8				
9				
10	10.76	305	24	29
11	10.55	305	22	28
12	12.96	305	2	37

Table 4-16. (Continued). Wind Speed Maximum Key Feature Values.

	Maximum Value (m/s)	Height of Maximum (m)	Time of Maximum (hr)	Wind Speed Shear (sec^{-1})
1978				
1				
2	11.47	305	6	33
3				
4				
5				
6	8.84	305	24	25
7	9.30	305	24	26
8	6.91	305	24	19
9				
10				
11				
12	12.4	305	22	35
1979				
1	11.62	305	2	30
2				
3				
4				
5				
6	10.52	305	4	30
7				
8	7.87	305	4	22
9	10.29	305	22	29
10	10.79	305	24	31

Table 4-17. Maximum Horizontal Wind Direction Key Feature Values.

	Maximum (Deg/100m)	Height (m)	Time (hr)
1975			
1			
2	10.63	305	0
3	8.27	305	8
4			
5			
6	16.33	305	0
7			
8			
9	19.25	305	4
10	11.71	305	6
11			
12	16.99	243	8
1976			
1	8.12	305	8
2	9.31	305	6
3	12.39	305	6
4	12.28	243	6
5	17.37	243	6
6	9.84	243	2
7	12.65	243	4
8	19.50	305	2
9	22.03	305	4
10	22.88	305	2
11	17.52	305	4
12			
1977			
1	13.47	243	4
2	15.42	243	8
3	10.32	243	8
4			
5	17.22	305	4
6	11.73	343	6
7	17.94	305	6
8	32.20	305	6
9	17.29	305	4
10	13.44	305	4
11	18.86	305	8
12	7.06	305	4

Table 4-17. (Continued). Maximum Horizontal Wind Direction Key Feature Values.

	Maximum (Deg/100m)	Height (m)	Time (hr)
1978			
1	6.37	305	6
2	8.00	305	2
3	12.95	243	6
4	14.27	305	6
5	10.67	305	6
6	23.64	305	6
7	13.63	305	6
8	19.20	305	4
9	31.91	305	4
10	35.30	305	4
11	35.67	305	6
12	15.11	305	8
1979			
1	9.38	305	24
2	11.65	243	4
3	13.06	243	4
4	15.70	305	6
5	19.06	243	2
6	13.00	305	4
7			
8	15.59	305	4
9	4.57	305	2
10	12.79	243	6

Table 4-18. Standard Deviation of Vertical Wind Direction Fluctuation Key Feature Values for the 10-m Level.

	Average (deg)	Maximum (deg)	Time of (Maximum (hr)	Minimum (deg)	Time of Minimum (hr)
1975					
1	7.94	10.32	12	5.87	20
2	7.88	10.24	12	5.99	20
3	8.60	10.34	14	7.10	6
4					
5					
6	8.84	12.26	12	6.32	2
7					
8		15.92	12	4.69	24
9	8.97	12.75	12	5.75	22
10	8.28	13.37	12	5.07	20
11					
12	7.78	11.55	12	5.14	20
1976					
1					
2	10.19	17.43	14	7.06	22
3					
4	10.00	15.30	14	4.88	20
5	9.70	12.55	12	7.33	2
6	10.61	16.50	12	6.62	22
7	9.51	15.23	12	5.17	20
8					
9	10.43	16.17	12	6.24	20
10	9.43	14.80	12	5.76	20
11	10.77	14.45	10	7.31	20
12	10.87	13.12	14	9.93	2
1977					
1	11.39	13.57	12	10.09	2
2	12.27	20.08	14	8.17	4
3	9.94	13.16	14	7.64	20
4	11.20	16.69	14	6.46	4
5	12.50	21.14	12	6.05	2
6	11.26	15.80	12	7.15	24
7	11.92	18.11	12	6.52	4
8	10.55	17.46	12	5.16	6
9					
10	10.35	15.37	12	5.17	20
11	9.53	14.49	12	5.56	2
12	11.60	15.18	12	9.48	20

Table 4-18. (Continued). Standard Deviation of Vertical Wind Direction Fluctuation Key Feature Values for the 10-m Level.

	Average (deg)	Maximum (deg)	Time of (Maximum (hr)	Minimum (deg)	Time of Minimum (hr)
1978					
1	11.51	14.19	14	9.72	2
2	11.18	15.79	14	7.01	20
3	11.69	15.62	12	8.07	20
4	11.16	15.86	12	5.96	20
5	11.23	16.29	14	6.68	4
6	11.71	17.87	12	5.85	4
7	12.23	16.82	12	8.31	2
8					
9					
10					
11					
12	12.75	16.26	14	10.48	8
1979					
1	15.44	18.50	12	13.70	24
2	14.20	21.25	14	10.53	22
3	12.57	17.29	12	9.59	2
4					
5					
6	12.11	16.79	10	7.64	22
7				6.12	4
8	10.47	18.02	12	5.01	2
9	14.81	17.37	12	11.53	20
10	16.33	23.27	12	11.39	20

Table 4-19. Standard Deviation of the Horizontal Wind Direction Fluctuation Key Feature Values for the 10-m Level.

	Average (deg)	Maximum (deg)	Time of Maximum (hr)	Minimum (deg)	Time of Minimum (hr)
1975					
1	11.44	16.29	14	8.29	20
2	11.74	16.17	12	9.15	20
3	11.00	14.87	12	8.64	2
4		13.12	12	2.90	20
5					
6	14.21	22.35	12	9.62	4
7					
8					
9	15.16	24.25	12	10.71	22
10	13.85	26.11	14	8.25	20
11					
12	13.20	21.77	12	9.69	20
1976					
1	14.51	22.44	14	11.00	20
2	13.08	22.00	14	8.75	20
3	13.04	19.70	14	9.26	4
4	14.93	25.08	12	7.90	20
5	14.53	20.59	14	10.53	4
6	15.65	25.30	12	10.21	22
7	15.85	27.04	14	10.12	20
8	15.17	27.28	12	9.48	2
9	13.93	22.48	12	8.79	20
10	13.68	24.22	12	8.23	4
11	14.31	22.09	14	9.70	20
12					
1977					
1	17.18	24.83	16	13.50	24
2	17.39	34.31	14	9.27	6
3				10.34	6
4				9.72	4
5	17.92	31.33	14	10.00	2
6	21.15	36.32	12	11.86	22
7		38.14	12	12.22	4
8		26.97	14	9.65	6
9					
10		26.38	14	10.34	20
11	14.46	22.56	14	10.66	20
12	15.99	21.61	14	13.33	20

Table 4-19. (Continued). Standard Deviation of the Horizontal Wind Direction Fluctuation Key Feature Values for the 10-m Level.

	Average (deg)	Maximum (deg)	Time of Maximum (hr)	Minimum (deg)	Time of Minimum (hr)
1978					
1	17.00	20.98	14	14.39	20
2	16.68	26.64	14	10.86	20
3	17.65	28.23	14	10.89	20
4	17.47	26.73	14	9.96	20
5	17.01	24.69	12	11.63	20
6	18.38	30.47	12	11.68	4
7	19.20	31.09	12	12.29	4
8	18.05	32.31	12	10.38	4
9	17.85	34.17	12	9.97	24
10	17.34	32.91	12	9.58	20
11	15.71	27.28	14	9.46	20
12	16.34	23.83	14	11.52	20
1979					
1	17.92	25.33	14	14.51	20
2	16.89	22.89	14	12.84	2
3	16.63	24.97	14	11.33	20
4	16.81	23.92	12	10.39	6
5	17.44	26.03	12	12.34	4
6	18.90	30.60	12	10.62	22
7					
8	22.00	38.04	14	11.32	6
9	19.14	26.72	12	14.04	20
10	16.03	29.81	12	8.37	20

Table 4-20. Summary Statistics for Key Features for Which a Seasonal Dependence Proved Significant. N is the Number of Data Values. a, b and d are Defined in Equation (1). The Values Within the Brackets are the 95% Confidence Bounds. The Units are Given to the Left for Each Feature.

	N	a	[a]	b	[b]	d
Potential Temperature						
10-m level						
Average (C)	54	17.0	[16.4, 17.6]	-10.9	[-11.9, -9.9]	$\pi/3$
Maximum (C)	55	22.4	[21.6, 23.1]	-11.0	[-12.1, -9.8]	$\pi/3$
Minimum (C)	54	12.6	[12.1, 13.1]	-10.8	[-11.6, -9.9]	$\pi/3$
Nocturnal structure						
304-m level (C)	49	18.8	[18.1, 19.6]	-8.6	[-9.8, -7.4]	$\pi/3$
Inversion (C/100m)*	54	2.2	[2.0, 2.4]	0.8	[0.5, 1.0]	$\pi/2$
Wind Speed						
10-m level						
Average (m/s)*	45	2.4	[2.3, 2.5]	0.4	[0.2, 0.5]	$\pi/6$
Maximum (m/s)	49	3.2	[3.0, 3.3]	0.5	[0.3, 0.7]	$\pi/6$
Minimum (m/s)	48	1.8	[1.7, 1.9]	0.3	[0.2, 0.4]	$\pi/6$
Nocturnal structure						
Maximum (m/s)	31	10.4	[10.00, 10.8]	2.2	[1.6, 2.8]	$\pi/3$
Wind speed gradient (s^{-1}x100)*	28	29.9	[28.1, 31.7]	6.0	[3.1, 8.8]	$\pi/3$

*Not significant at the 0.05 level, but seasonal dependence is strongly suggested by other related key features.

Table 4-21. Summary Statistics for Key Features for Which a Seasonal Dependence did not Prove Significant. N is the Number of Data Values, y, is the Annual Average and s^2 is the Variance. The Values Within the Brackets are the 95% Confidence Bounds. The Units are Given to the Left for Each Feature.

	N	y	[y]	s^2	[s^2]
Potential Temperature					
10-m level					
Time of maximum (hr)	55	15.0	[14.7, 15.2]	1.0	[0.7, 1.5]
Time of minimum (hr)	54	5.5	[5.1, 5.9]	2.4	[1.7, 3.7]
Nocturnal structure					
Inversion (C/100m)	54	2.1	[1.9, 2.4]	0.8	[0.6, 1.2]
Wind Speed					
10-m level					
Average (m/s)	45	2.4	[2.3, 2.5]	0.2	[0.1, 0.3]
Time of maximum (hr)	49	14.1	[13.6, 14.7]	3.4	[2.4, 5.3]
Time of minimum (hr)	48	0.7	[23.3, 2.1]	22.2	[15.4, 24.9]
Nocturnal structure					
Time of maximum (hr)	31	1.2	[0.3, 2.0]	5.5	[3.5, 9.9]
Wind speed gradient (s^{-1}x100)	28	29.2	[26.8, 31.6]	39.4	[24.6, 73.0]
Wind Direction Shear					
Time of maximum (hr)	49	4.8	[4.2, 5.4]	4.6	[3.2, 7.2]
Maximum (degrees)	49	15.6	[13.6, 17.6]	48.5	[33.8, 75.8]

5.0 CONCLUSION

The previous sections summarized the data processing completed on the five year data set of meteorological tower data collected by the Meteorology Group of the Savannah River Laboratory. This data set provides a unique opportunity to study micrometeorological processes within the lower 300 meters of the atmosphere. The purpose of this document is met if it provides potential user's of these data the information needed to access the data files.

It is anticipated that user's of these data have access to the EPA Sperry UNIVAC computer. No plans have been made to provide copies of the data for use on other computer systems. Inquiries for gaining access to the data should be addressed to:

Chief, Environmental Operations Branch (MD-80)

Meteorology Division

Environmental Protection Agency

Research Triangle Park, NC 27711.

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